JOURNAL AND PROCEEDINGS

OF THE

ROYAL SOCIETY

OF

NEW SOUTH WALES,

EDITED BY

THE HONORARY SECRETARIES.

THE AUTHORS OF PAPERS ARE ALONE RESPONSIBLE FOR THE OPINIONS EXPRESSED THEREIN.

PUBLISHED BY THE SOCIETY, 5 ELIZABETH STREET NORTH, SYDNEY.
LONDON AGENTS:
GEORGE ROBERTSON & Co., PROPRIETARY LIMITED,
17 WARWICK SQUARE, PATERNOSTER ROW, LONDON, E.C.

1905.

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VOLUME XXXIX.

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OF THE

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OF

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FOR

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(INCORPORATED 1881.)

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NOTICE.

The Royal Society of New South Wales originated in 1821 as the "Philosophical Society of Australasia"; after an interval of inactivity, it was resuscitated in 1850, under the name of the "Australian Philosophical Society," by which title it was known until 1856, when the name was changed to the "Philosophical Society of New South Wales"; in 1866, by the sanction of Her Most Gracious Majesty the Queen, it assumed its present title, and was incorporated by Act of the Parliament of New South Wales in 1881.

TO AUTHORS.

Authors of papers desiring illustrations are advised to consult the editors (Honorary Secretaries) before preparing their drawings. Unless otherwise specially permitted, such drawings should be carefully executed to a large scale on smooth white Bristol board in intensely black Indian ink, so as to admit of the blocks being prepared directly therefrom, in a form suitable for photographic "process." The size of a full page plate in the Journal is $4\frac{1}{4}$ in. $\times$ $6\frac{3}{4}$ in. The cost of all original drawings, and of colouring plates must be borne by Authors.

PUBLICATIONS.

The following publications of the Society, if in print, can be obtained at the Society's House in Elizabeth-street:—

Transactions of the Philosophical Society, N.S.W., 1862-5, pp. 374, out of print.

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Royal Society of New South Wales.

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Assistant Secretary:

W. H. WEBB.

FORM OF BEQUEST.

I bequeath the sum of £   to the Royal Society of New South Wales, Incorporated by Act of the Parliament of New South Wales in 1881, and I declare that the receipt of the Treasurer for the time being of the said Corporation shall be an effectual discharge for the said Bequest, which I direct to be paid within   calendar months after my decease, without any reduction whatsoever, whether on account of Legacy Duty thereon or otherwise, out of such part of my estate as may be lawfully applied for that purpose.

[*Those persons who feel disposed to benefit the Royal Society of New South Wales by Legacies, are recommended to instruct their Solicitors to adopt the above Form of Bequest.*]

NOTICE.

Members are particularly requested to communicate any change of address to the Hon. Secretaries, for which purpose this slip is inserted.

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Name..

....

Titles, &c..

....

Address...

....

....

Date..........................

To the

Hon. Secretaries,

The Royal Society of N. S. Wales,

5 Elizabeth Street, Sydney.

LIST OF THE MEMBERS

OF THE

Royal Society of New South Wales.

P Members who have contributed papers which have been published in the Society's Transactions or Journal; papers published in the Transactions of the Philosophical Society are also included. The numerals indicate the number of such contributions.

‡ Life Members.

Elected.		
1877	P 5	Abbott, W. E., 'Abbotsford,' Wingen.
1895		Adams, J. H. M., Broughton Cottage, St. James' Rd., Waverley.
1904		Adams, William John, M. I. Mech. E., 163 Clarence-street.
1890	P 2	Allan, Percy, M. Inst. C.E., Assoc. M. Am. Soc. C.E., Engineer-in-Charge of Bridge Design, Public Works Department, Sydney.
1898		Alexander, Frank Lee, c/o Messrs. Goodlet and Smith Ld., Cement Works, Granville.
1905		Anderson, Charles, M.A., B.Sc., *Edin.*, 'Moa,' Roslyn Gardens, Darlinghurst.
1903		Arnot, Arthur James, A.M.I.C.E., M.I.M.E., M.I.E.E., Electrical Engineer, 83 Pitt-street.
1902		Arnott, John M., 'Strathfield,' Strathfield.
1899	P 1	Atkinson, A. A., Chief Inspector of Collieries, Department of Mines, Sydney.
1878		Backhouse, Alfred P., M.A., District Court Judge, 'Melita,' Elizabeth Bay.
1894	P 9	Baker, Richard Thomas, F.L.S., Curator, Technological Museum.
1900		Bale, Ernest, C.E., Public Works Department.
1894		‡Balsille, George, 'Lauderdale,' N.E. Valley, Dunedin, N.Z.
1896		Barff, H. E., M.A., Registrar, Sydney University.
1895	P 10	Barraclough, S. Henry, B.E., M.M.E., Assoc. M. Inst. C.E. Memb. Soc. Promotion Eng. Education; Memb. Internat. Assoc. Testing Materials; Lecturer in Mechanism and Applied Thermodynamics, Sydney University; pr. 'Marmion,' Victoria-street, Lewisham.
1903		Bayly, Francis William, Assayer, Royal Mint, Sydney.
1894		Baxter, William Howe, Chief Surveyor Existing Lines Office, Railway Department, Bridge-street.
1877		Belfield, Algernon H., 'Eversleigh,' Dumaresq.
1876		Benbow, Clement A., 48 College-street.
1900		Bender, Ferdinand, Accountant and Auditor, 21 Elizabeth-street, North.
1869	P 2	Bensusan, S. L., Equitable Building, George-st., Box 411, G.P.O.
1905		Bignold, Hugh Baron, Barrister-at-Law, Chambers, Wentworth Court, 64 Elizabeth-street.
1901		Birks, Lawrence, B.Sc., Assoc. M. Inst. C.E., A.M.I.E.E., F.G.S., City Electrical Engineer, Christchurch, New Zealand.
1905		Blakemore, George Henry, General Manager for the Great Cobar Mining Syndicate, Lithgow.

Elected		
1888		‡Blaxland, Walter, F.R.C.S. *Eng.*, L.R.C.P. *Lond.*, Fremantle, West Australia.
1893		Blomfield, Charles E., B.C.E. *Melb.*, 'Woombi,' Kangaroo Camp, Guyra.
1898		Blunno, Michele. Licentiate in Science (Rome), Government Viticultural Expert, Department of Agriculture, Sydney.
1905		Board, Peter, M.A. *Syd.*, Under Secretary and Director of Education, Department of Public Instruction, Sydney.
1879		‡Bond, Albert, 131 Bell's Chambers, Pitt-street.
1904		Bosch, Ernest, Consulting Optician, Mutual Life Building, Martin Place.
1891		Bowman, Archer S., B.E., 'Keadue,' Elizabeth Bay Road.
1893		Bowman, John, Assoc. M. Inst. C.E., c/o T. A. Kemmis, Esq., 163 Phillip-street.
1876		Brady, Andrew John, Lic. K. & Q. Coll. Phys. *Irel.*, Lic. R. Coll. Sur. *Irel.*, 3 Lyons Terrace, Hyde Park.
1891		Brennand, Henry J. W., B.A., M.B., Ch. M. *Syd.*, F.R.A.S., F.C.S., 231 Macquarie-street.
1902		Brereton, Victor Le Gay, Solicitor, Tattersall's Chambers, Hunter-st.; p.r. 'Osgathorpe,' Gladesville.
1878		‡Brooks, Joseph, F.R.A.S., F.R.G.S., 'Hope Bank,' Nelson-street, Woollahra.
1876		Brown, Henry Joseph, Solicitor, Newcastle.
1903		Bruck, Ludwig, Medical Publisher, 15 Castlereagh-street.
1898		‡Burfitt, W. Fitzmaurice, B.A., B.Sc., M.B., Ch. M. *Syd.*, 311 Glebe Road, Glebe Point.
1890		Burne, Dr. Alfred, Dentist, 1 Lyons Terrace, Liverpool-street.
1880		Bush, Thomas James, M. Inst. C.E., Engineer's Office, Australian Gas-Light Company, 153 Kent-street.
1904		Cambage, Richard Hind, F.L.S., Chief Mining Surveyor, Park Road, Burwood.
1904		Cameron, John Mindoro, Assoc. M. Inst. C.E., Engineer, Public Works Department; p.r. Hotel Metropôle, Sydney.
1900		Canty, M., 'Rosemont,' 13 York-street, Wynyard Square.
1876		Cape, Alfred J., M.A. *Syd.*, 'Karoola,' Edgecliffe Rd., Edgecliffe.
1897	P 3	Cardew, John Haydon, Assoc. M. Inst. C.E., L.S., 75 Pitt-street.
1901		Card, George William, A.R.S.M., F.G.S., Curator and Mineralogist to the Geological Survey, N.S.W., Department of Mines.
1891		Carment, David, F.I.A. *Grt. Brit. & Irel.*, F.F.A. *Scot.*, Australian Mutual Provident Society, 87 Pitt-st. *Hon. Treasurer.*
1903		Carslaw, H. S., M.A., D.Sc., Professor of Mathematics, Sydney University, Glebe.
1879	P 1	‡Chard, J. S., Licensed Surveyor, Armidale.
1878		Chisholm, Edwin, M.R.C.S. *Eng.*, L.S.A. *Lond.*, Victoria-street, Ashfield.
1885		Chisholm, William, M.D. *Lond.*, 139 Macquarie-street, North.
1896	P 1	Cook, W. E., M.C.E. *Melb.*, M. Inst. C.E. District Engineer, Water and Sewerage Department, North Sydney.
1904		Cooksey, Thomas, Ph. D., B.Sc. *Lond.*, F.I.C., Second Government Analyst; p.r. 'Clissold,' Calypso Avenue, Mosman.
1903		Cooper, David John, M.A., 'Grasmere,' 151 Stanmore Road, Stanmore.

Elected		
1876		Codrington, John Frederick, M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, L.R.C.P. *Edin.*, 'Wynwood,' Wahroonga.
1876		Colyer, J. U. C., 'Malvern,' Collingwood and Seymour-streets, Drummoyne.
1882		Cornwell, Samuel, Australian Brewery, Bourke-st., Waterloo.
1891		Coutie, W. H., M.B., Ch.B. *Melb.*, 'Warminster,' Canterbury Road, Petersham.
1892	P 1	Cowdery, George R., Assoc. M. Inst. C.E., Engineer for Tramways, Phillip-st.; p.r. 'Glencoe,' Torrington Road, Strathfield.
1886		Crago, W. H., M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, 16 College-street, Hyde Park.
1905		Dampney, Gerald F., Fellow of the Society of Chemical Industry, 'Doonbah,' Hunter's Hill.
1875		Dangar, Fred. H., c/o Messrs. Dangar, Gedye, & Co., Mercantile Bank Chambers, Margaret-street.
1890		Dare, Henry Harvey, M.E., Assoc. M. Inst. C.E., Roads and Bridges Branch, Public Works Department.
1876	P 3	Darley, Cecil West, M. Inst. C.E., 34 Campden Hill Court, Campden Hill Road, Kensington, London, W.
1877		Darley, The Hon. Sir Frederick, G.C.M.G., B.A., Chief Justice, Supreme Court.
1886	P 18	David, T. W. Edgeworth, B.A., F.G.S., F.R.S., Professor of Geology and Physical Geography, Sydney University, Glebe.
1892	P 1	Davis, Joseph, M. Inst. C.E., Under Secretary, Department of Public Works.
1885	P 2	Deane, Henry, M.A., M. Inst. C.E. Hoskins' Building, Spring-st.; p.r. 'Blanerne,' Wybalena Road, Hunter's Hill.
1877		Deck, John Feild, M.D. Univ. *St. Andrews*, L.R.C.P. *Lond.*, M.R.C.S. *Eng.*, 203 Macquarie-st; p.r. 92 Elizabeth-st., Ashfield.
1899	P 1	De Coque, J. V., c/o Messrs. Gibbs, Bright & Co., 37 Pitt-st.
1894		Dick, James Adam, B.A., *Syd.*, M.D., C.M. *Edin.*, 'Catfoss,' Belmore Road, Randwick.
1875	P 12	Dixon, W. A., F.C.S., Fellow of the Institute of Chemistry of Great Britain and Ireland, 97 Pitt-street.
1880		Dixson, Thomas Storie, M.B. *Edin.*, Mast. Surg. *Edin.*, 287 Elizabeth-street, Hyde Park.
1876		Docker, Ernest B., M.A. *Syd.*, District Court Judge, 'Eltham, Edgecliffe Road.
1899		Duckworth, A., A.M.P. Society, 87 Pitt-st.; p.r. 'Trentham,' Woollahra.
1873	P 1	Du Faur, E., F.R.G.S., 'Flowton,' Turramurra.
1879	P 4	Etheridge, Robert, Junr., J.P., Curator, Australian Museum; p.r. 21 Roslyn-street, Darlinghurst
1876		Evans, George, Fitz Evan Chambers, Castlereagn-street.
1904		Evans, James W., Chief Inspector, Weights and Measures; p.r. 'Glenthorne,' 4 Railway-street, Petersham.

Elected		
1877		‡Fairfax, Edward Ross, *S. M. Herald* Office, Hunter-street.
1896		Fairfax, Geoffrey E., *S. M. Herald* Office, Hunter-street.
1868		Fairfax, Sir James R., Knt., *S. M. Herald* Office, Hunter-st.
1887		Faithfull, R. L., M.D., *New York* (Coll. Phys. & Surg.), L.R.C.P., L.S.A. *Lond.*, 18 Wylde-street.
1902		Faithfull, William Percy, Barrister-at-Law, Australian Club.
1897		Fell, David, M.L.A., C.A.A., Public Accountant, Equitable Building, George-street.
1881		Fiaschi, Thos. M.D., M.Ch. *Pisa*, 149 Macquarie-street.
1888		Fitzhardinge, Grantly Hyde, M.A. *Syd.*, District Court Judge, 'Red Hill,' Beecroft, Northern Line.
1900		‡Flashman, James Froude, M.D. *Syd.*, Jersey Road, Burwood.
1902		Fleming, Edward G., A.M.I.E.E., 16 O'Connell-street.
1879		‡Foreman, Joseph, M.R.C.S. *Eng.*, L.R.C.P. *Edin.*, 141 Macquarie-st.
1881		Foster, The Hon. W. J., K.C., 'Thurnby,' 35 Enmore Road, Newtown.
1905		Foy, Mark, 'Eumemering,' Bellevue Hill, Woollahra.
1904		Fraser, James, M. Inst. C.E., Engineer-in-Chief for Existing Lines, Bridge-street; p.r. 'Arnprior,' Neutral Bay.
1899		French, J. Russell, General Manager, Bank of New South Wales, George-street.
1881		Furber, T. F., F.R.A.S., 'Wavertree,' Kurraba Road, Neutral Bay.
1899		Garran, R. R., M.A., C.M.G., Commonwealth Offices, Spring-st., Melbourne.
1876		George, W. R., 318 George-street.
1879		Gerard, Francis, 'The Grange,' Monteagle, near Young.
1896		Gibson, Frederick William, District Court Judge, 'Grasmere,' Stanmore Road.
1859		Goodlet, J. H., 'Canterbury House,' Ashfield.
1897		Gould, Major The Hon. Albert John, Senator, 'Eynesbury,' Edgecliffe.
1891	P 1	Grimshaw, James Walter, M. Inst. C.E., M. I. Mech. E., &c., Australian Club.
1899	P 2	Gummow, Frank M., M.C.E., Vickery's Chambers, 82 Pitt-st.
1891	P 11	Guthrie, Frederick B., F.I.C., F.C.S., Chemist, Department of Agriculture, 136 George-street, Sydney. *Vice-President.*
1880	P 2	Halligan, Gerald H., F.G.S., 'Riversleigh,' Hunter's Hill.
1899		Halloran, Aubrey, B.A., LL.B., Savings Bank Chambers, Moore-street.
1892		Halloran, Henry Ferdinand, L.S., Scott's Chambers, 94 Pitt-st.
1887	P 7	Hamlet, William M., F.I.C., F.C.S., Member of the Society of Public Analysts; Government Analyst, Health Department, Macquarie-street, North.
1905	P 1	Harker, George, D.Sc., 35 Boulevarde, Petersham.
1881		‡Harris, John, 'Bulwarra,' Jones-street, Ultimo.
1887	P 18	‡Hargrave, Lawrence, Wunulla Road, Woollahra Point.
1884	P 1	Haswell, William Aitcheson, M.A., D.Sc., F.R.S., Professor of Zoology and Comparative Anatomy, University, Sydney; p.r. 'Mimihau,' Woollahra Point.

Elected		
1900		Hawkins, W. E., Solicitor, 88 Pitt-street.
1890	P 2	Haycroft, James Isaac, M.E. Queen's Univ. *Irel.*, Assoc. M. Inst. C.E. Assoc. M. Cam. Soc. C.E., Assoc. M. Am. Soc. C.E., M.M. & C.E., M. Inst. C.E.I., L.S. 'The Grove,' off Queen-street, Woollahra.
1891	P 1	Hedley, Charles, F.L.S., Assistant in Zoology, Australian Museum, Sydney.
1900	P 3	Helms, Richard, Experimentalist, Department of Agriculture.
1902		Hennessy, John Francis, Architect, Ashpitel Prizeman and Silver Medallist, Royal Institute of British Architects, City Chambers, 243 Pitt-street.
1899		Henderson, J., F.R.E.S., Manager, City Bank of Sydney, Pitt-st.
1899		Henderson, S., M.A., Assoc M. Inst. C.E., Equitable Building, George-street.
1884	P 1	Henson, Joshua B., Assoc. M. Inst. C.E., Hunter District Water Supply and Sewerage Board, Newcastle.
1904		Hill, John Whitmore, Architect, 'Willamere,' May's Hill, Parramatta.
1876	P 2	Hirst, George D., F.R.A.S., 379 George-street.
1896		Hinder, Henry Critchley, M.B., C.M. *Syd.*, Elizabeth-st., Ashfield.
1892		Hodgson, Charles George, 157 Macquarie-street.
1901		Holt, Thomas S., 'Holwood,' Victoria-street, Ashfield.
1904		Holt, Rev. Wilfred John, M.A., 'Kiora,' Blackheath.
1905		Hooper, George, Registrar, Sydney Technical College; p.r. 'Branksome,' Henson-street, Summer Hill.
1905		Hoskins, George J., Burwood Road, Burwood.
1891	P 2	Houghton, Thos. Harry, M. Inst. C.E., M. I. Mech. E., 63 Pitt-street.
1894	P 2	Hunt, Henry A., F. R. Met. Soc., Acting Government Meteorologist, Sydney Observatory.
1905		Hyde, Ellis, Analyst, 27 York-street.
1903		Irvine, R. F., M.A., Examiner for Public Service Board; p.r. Musgrave-street, Mosman.
1891		Jamieson, Sydney, B.A., M.B., M.R.C.S., L.R.C.P., 189 Liverpool-street, Hyde Park.
1904		Jaquet, John Blockley, A.R.S.M., F.G.S., Acting Chief Inspector of Mines, Geological Surveyor, 'Cromer,' 91 Phillip-street.
1900		Jarman, Arthur, A.R.S.M., Demonstrator in Assaying and Chemistry, University of Sydney.
1903		Jenkinson, Edward H., M. I. Mech. E., 13 and 15 Macquarie Place.
1904		Jenkins, R. J. H., Fisheries Commissioner, 'Pyalla,' 13A Selwyn street, Moore Park.
1905	P 2	Jensen, Harold Ingemann, B. Sc., Macleay Fellow of the Linnean Society of New South Wales, Sydney University.
1902	P 1	Jevons, H. Stanley, M.A. *Cantab.*, B. Sc., *Lond.*, University College of South Wales and Monmouthshire, Cardiff.
1902		Jones, Henry L., Assoc. M. Am. Soc. C.E., 14 Martin Place.
1884		‡Jones, Llewellyn Charles Russell, Solicitor, Falmouth Chambers, 117 Pitt-street.
1867		Jones, Sir P. Sydney, Knt., M.D. *Lond.*, F.R.C.S. *Eng.*, 16 College street, Hyde Park; p.r. 'Llandilo,' Boulevard, Strathfield.

Elected		
1876	P 2	Josephson, J. Percy, Assoc. M. Inst. C.E., Stephen Court, 81 Elizabeth-street; p.r. 'Moppity,' George-street, Dulwich Hill.
1878		Joubert, Numa, Hunter's Hill.
1883		Kater, The Hon. H. E., J.P., M.L.C., Australian Club.
1873		Keele, Thomas William, M. Inst. C.E., President, Metropolitan Board of Water Supply and Sewerage, 341 Pitt-street.
1887		Kent, Harry C., M.A., Bell's Chambers, 129 Pitt-street.
1903	P 1	Kennedy, Thomas, Assoc. M. Inst. C.E., Railway Construction Branch, Public Works Department.
1901		Kidd, Hector, M. Inst. C.E., 'Craig Lea,' 15 Mansfield-street, Glebe Point.
1891		King, Christopher Watkins, Assoc. M. Inst. C.E., L.S., Assistant Engineer, Harbours and Rivers Department, Newcastle.
1896		King, Kelso, 120 Pitt-street.
1892		Kirkcaldie, David, Commissioner, New South Wales Government Railways, Sydney.
1878		Knaggs, Samuel T., M.D. *Aberdeen*, F.R.C.S. *Irel.*, 1 Lyons Terrace, Hyde Park.
1881	P 17	Knibbs, G. H., F.R.A.S., Memb. Internat. Assoc. Testing Materials; Memb. Brit. Sc. Guild; 'Spottiswoode,' 28 Bland-street, Ashfield. *Hon. Secretary.*
1877		Knox, Edward W., 'Rona,' Bellevue Hill, Double Bay.
1878		Kyngdon, F. B., F.R.M.S. *Lond.*, Deanery Cottage, Bowral.
1874	P 2	Lenehan, Henry Alfred, F.R.A.S., Acting Government Astronomer, Sydney Observatory. *President.*
1901		Lindeman, Charles F., Wine Merchant, Jersey Rd., Strathfield.
1883		Lingen, J. T., M.A. *Cantab.*, 167 Phillip-street.
1901		Little, Robert, 'The Hermitage,' Rose Bay.
1872	P 55	Liversidge, Archibald, M.A. *Cantab.*, LL.D., F.R.S., Hon. F.R.S. *Edin.*, Assoc. Roy. Sch. Mines, *Lond.*; F.C.S., F.G.S., F.R.G.S.; Fel. Inst. Chem. of Gt. Brit. and Irel., Hon. Fel. Roy. Historical Soc. *Lond.*; Mem. Phy. Soc. *Lond.*; Mineralogical Society, *Lond.*; Edin. Geol. Soc.; Mineralogical Society, *France*; Corr. Mem. Edin. Geol. Soc.; New York Acad. of Sciences; Roy. Soc., *Tas.*; Roy. Soc., *Queensland*; Senckenberg Institute, *Frankfurt*; Société d' Acclimat., *Mauritius*; Foreign Corr. Indiana Acad. of Sciences; Hon. Mem. Roy. Soc., *Vict.*; N. Z. Institute; K. Leop. Carol. Acad., *Halle a/s*; Professor of Chemistry in the University of Sydney, The University, Glebe; p.r. 'The Octagon,' St. Mark's Road, Darling Point. *Vice-President.*
1884		MacCormick, Alexander, M.D., C.M. *Edin.*, M.R.C.S. *Eng.*, 125 Macquarie-street, North.
1887		MacCulloch, Stanhope H., M.B., C.M. *Edin.*, 24 College-street.
1892		McDonagh, John M., B.A., M.D., M.R.C.P. *Lond.*, F.R.C.S. *Irel.*, 173 Macquarie-street, North.

Elected		
1897		MacDonald, C. A., C.E., 63 Pitt-street.
1878		MacDonald, Ebenezer, J.P., c/o Perpetual Trustee Co. Ld., 2 Spring-street.
1868		MacDonnell, William J., F.R.A.S., 4 Falmouth Chambers, 117 Pitt-street.
1903		McDonald, Robert, J.P., Acting Under Secretary for Lands, p.r. 'Wairoa,' Holt-street, Double Bay.
1891		McDouall, Herbert Crichton, M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, D.P.H. *Cantab.*, Hospital for Insane, Gladesville.
1904		MacFarlane, Edward, J.P., Under Secretary for Lands, 12 Fitzroy-street, Milson's Point, North Sydney.
1891	P 1	McKay, R. T., C.E., 'Tranquilla,' West-street, North Sydney.
1893		McKay, William J. Stewart, B.Sc., M.B., Ch.M., Cambridge-street. Stanmore.
1876		Mackellar, The Hon. Charles Kinnaird, M.L.C., M.B., C.M. *Glas.*, Equitable Building, George-street.
1904		McKenzie, Robert, Sanitary Inspector, (Water and Sewerage Board), 'Stonehaven Cottage, Bronte Road, Waverley.
1880	P 9	McKinney, Hugh Giffin, M.E. Roy. Univ. *Irel.*, M. Inst. C.E., Exchange, 56 Pitt-street; p.r. 'Dilkhusha,' Fuller's Road, Chatswood.
1903		McLaughlin, John, Solicitor, Clement's Chambers, 88 Pitt-st.
1876		MacLaurin. The Hon. Sir Henry Normand, M.L.C., M.A., M.D, L.R.C.S. *Edin.*, LL.D. *St. Andrews*, 155 Macquarie-street.
1901	P 1	McMaster, Colin J., Chief Commissioner of Western Lands; p.r. Wyuna Road, Woollahra Point.
1894		McMillan, Sir William, 'Logan Brae,' Waverley.
1900		MacTaggart, A. H., D.D.S. *Phil.* U.S.A., King and Phillip-sts.
1899		MacTaggart, J. N. C., M.E, *Syd.*, Assoc. M. Inst. C.E., Water and Sewerage Board, 341 Pitt-street.
1882	P 1	Madsen, Hans F., 'Hesselmed House,' Queen-st., Newtown.
1883	P 15	Maiden, J. Henry, J.P., F.L.S., Hon. Fellow Roy. Soc., S.A.; Hon. Memb. Nat. Hist. Soc., W.A.; Netherlands Soc. for Promotion of Industry; Philadelphia Coll. Pharm.; Pharm. Soc. N.S.W.; Brit. Pharm. Conf.; Corr. Fellow Therapeutical Soc. Lond.; Corr. Memb. Pharm. Soc. Great Britain; Bot. Soc. Edin.; Soc. Nac. de Agricultura (Chile); Soc. d' Horticulture d' Alger; Union Agricole Calédonienne; Soc. Nat. etc. de Chérbourg; Roy. Soc., Tas.; Government Botanist and Director, Botanic Gardens, Sydney. *Hon. Secretary.*
1880	P 1	Manfred, Edmund C., Montague-street, Goulburn.
1897		Marden, John, B.A., M.A., LL.B. *Melb.*, LL.D. *Syd.*, Principal, Presbyterian Ladies' College, Sydney.
1875	P 20	Mathews, Robert Hamilton, L.S., Assoc. Etran. Soc. d' Anthrop. de Paris; Cor. Mem. Anthrop. Soc., Washington, U.S.A.; Cor. Mem. Anthrop. Soc. Vienna; Cor. Mem. Roy. Geog. Soc. Aust., Queensland; 'Carcuron,' Hassall-st., Parramatta.
1903		Meggitt, Loxley, Manager Co-operative Wholesale Society, Alexandria.
1896	P 7	Merfield, Charles J., F.R.A.S., Mitglieder der Astronomischen Gesellschaft, Observatory Sydney.
1905		Miller, James Edward, Cobar.

Elected		
1887		Miles, George E., L.R.C.P. *Lond.*, M.R.C.S. *Eng.*, The Hospital, Rydalmere, near Parramatta.
1903		Minell, W. Percy, Incorporated Accountant, Martin Chambers, Moore-street.
1889	P 3	Mingaye, John C. H., F.I.C., F.C.S., Assayer and Analyst to the Department of Mines, Government Metallurgical Works, Clyde; p.r. Campbell-street, Parramatta.
1879		Moore, Frederick H., Illawarra Coal Co., Gresham-street.
1877		‡Mullens, Josiah, F.R.G.S., 'Tenilba,' Burwood.
1879		Mullins, John Francis Lane, M.A. *Syd.*, 'Killountan,' Challis Avenue, Pott's Point.
1887		Munro, William John, B.A., M.B., C.M., M.D. *Edin.*, M.R.C.S. *Eng.*, 213 Macquarie-street; p.r. 'Forest House,' 182 Pyrmont Bridge Road, Forest Lodge.
1876		Myles, Charles Henry, 'Dingadee,' Burwood.
1893		Nangle, James, Architect, Australia-street, Newtown.
1901		Newton, Roland G., 'Walcott,' Boyce-street, Glebe Point.
1891		‡Noble, Edwald George, Public Works Department, Newcastle.
1873		Norton, The Hon. James, M.L.C., LL.D., Solicitor, 2 O'Connell-street; p.r. 'Ecclesbourne,' Ocean-street, Edgecliffe.
1893		Noyes, Edward, Assoc. Inst. C.E., Assoc. I. Mech. E., c/o Messrs. Noyes Bros., 109 Pitt-street.
1903		Old, Richard, Solicitor, 'Waverton,' Bay Rd., North Sydney.
1896		Onslow, Lt. Col. James William Macarthur, Camden Park, Menangle.
1875		O'Reilly, W. W. J., M. D., M. Ch., Q. Univ. *Irel.*, M.R.C.S. *Eng.*, 197 Liverpool-street, Hyde Park.
1891		Osborn, A. F., Assoc. M. Inst. C.E., Public Works Department, Cowra.
1883		Osborne, Ben. M., J.P., 'Hopewood,' Bowral.
1903		Owen, Rev. Edward, B.A., All Saints' Rectory, Hunter's Hill.
1880		Palmer, Joseph, 96 Pitt-st.; p.r. Kenneth-st., Willoughby.
1878		Paterson, Hugh, 197 Liverpool-street, Hyde Park.
1901		Peake, Algernon, Assoc. M. Inst. C.E., 25 Prospect Road, Ashfield.
1899		Pearse, W., Union Club; p.r. Moss Vale.
1877		Pedley, Perceval R., 227 Macquarie-street.
1899		Petersen, T. Tyndall, Member of Sydney Institute of Public Accountants, Copper Mines, Burraga.
1879	P 6	Pittman, Edward F., Assoc. R.S.M., L.S., Under Secretary and Government Geologist, Department of Mines.
1896		Plummer, John, 'Northwood,' Lane Cove River; Box 413 G.P.O.
1881		Poate, Frederick, Lands Office, Moree.
1879		Pockley, Thomas F. G., Commercial Bank, Singleton.
1887	P 2	Pollock, James Arthur, B.E. Roy. Univ. *Irel.*, B.Sc. *Syd.*, Professor of Physics, Sydney University.
1896		Pope, Roland James, B.A. *Syd.*, M.D., C.M., F.R.C.S. *Edin.*, Ophthalmic Surgeon, 235 Macquarie-street.

Elected		
1893		Purser, Cecil, B.A., M.B., Ch.M. *Syd.*, 'Valdemar,' Boulevard, Petersham.
1901	P 1	Purvis, J. G. S., Water and Sewerage Board, 311 Pitt-street.
1876		Quaife, F. H., M.A., M.D., Mast. Surg. *Glas.*, 'Hughenden,' 14 Queen-street, Woollahra. *Vice-President.*
1899	P 1	Rae, J. L. C., 'Endcliffe,' Church-street, Newcastle.
1902		Ramsay, Arthur A., Assistant Chemist, Department of Agriculture, 136 George-street.
1904		Ramsay, David, Surveyor. 'Liryclea,' Lyons Road, Five Dock.
1865	P 1	‡Ramsay, Edward P., LL.D. *St. And.*, F.R.S.E., F.L.S., 8 Palace-street, Petersham.
1901		Raymond, Robert S., 'Yarroville,' Goulburn.
1890		Rennie, George E., B.A. *Syd.*, M.D. *Lond*, M.R.C.S. *Eng.*, 159 Macquarie-street.
1870		‡Renwick, The Hon. Sir Arthur, Knt., M.L.C., B.A. *Syd.*, M.D., F.R.C.S. *Edin.*, 325 Elizabeth-street.
1902		Richard, G. A., Mount Morgan Gold Mining Co., Mount Morgan, Queensland.
1903	P 1	Rooke, Thomas, A.M.I C.E., Electrical Engineer, Town Hall, Sydney.
1893	P 1	Roberts, W. S. de Lisle, C.E., 'Kenilworth,' Penshurst.
1885		Rolleston, John C., Assoc. M. Inst. C.E., Harbours and Rivers Branch, Public Works Department.
1892		Rossbach, William, Assoc. M. Inst. C.E., Chief Draftsman, Harbours and Rivers Branch, Public Works Department.
1884		Ross, Chisholm, M.D. *Syd.*, M.B., C.M. *Edin.*, 147 Macquarie-st.
1895	P 1	Ross, Herbert E., Consulting Engineer and Architect, Equitable Building, George-street.
1904	P 2	Ross, William J. Clunies, B.Sc. *Lond. & Syd.*, F.G.S., Lecturer in Chemistry, Technical College, Sydney.
1882		Rothe, W. H., Colonial Sugar Co., O'Connell-street, and Union Club.
1864	P 69	Russell, Henry C., B.A. *Syd.*, C.M.G., F.R.S., F.R.A.S., F. R. Met. Soc., Hon. Memb. Roy. Soc. S. Australia, Sydney Observatory.
1897		Russell, Harry Ambrose, B.A., Solicitor, c/o Messrs. Sly and Russell, 369 George-street; p.r. 'Mahuru,' Fairfax Road, Bellevue Hill.
1893		Rygate, Philip W., M.A., B.E. *Syd.*, Assoc. M. Inst. C.E., Phœnix Chambers, 158 Pitt-street.
1905		Scheidel, August, Ph.D., Managing Director, Commonwealth Portland Cement Co., Sydney; Union Club.
1899		Schmidlin, F., 83 Elizabeth-street, Sydney.
1892	P 1	Schofield, James Alexander, F.C.S., A.R.S.M., University, Sydney.
1905		Scott, Ernest Kilburn, The University, Sydney.
1856	P 1	‡Scott, Rev. William, M.A. *Cantab.*, Kurrajong Heights.
1903		Scott, William B., Principal, Homebush Grammar School, p.r Albert Road, Strathfield.

Elected		
1877	P 4	Selfe, Norman, M. Inst. C.E., M. I. Mech. E., Victoria Chambers, 279 George-street.
1904	P 1	Sellors, R. P., B.A. *Syd.*, 'Cairnleith,' Springdale Road, Killara.
1891		Shaw, Percy William, M. Inst. C.E., Resident Engineer for Tramway Construction; p.r. 'Epcombs,' Miller-st. North Sydney.
1883	P 3	Shellshear, Walter, M. Inst. C.E., Inspecting Engineer, Existing Lines Office, Bridge-street.
1905		Simpson, D. C., Divisional Engineer, N. S. Wales Railways, Redfern; p.r. 'Omapere,' Lane Cove Road, North Sydney.
1900		Simpson, R. C., Technical College, Sydney.
1892		Sinclair, Eric, M.D., C.M. *Glas.*, Inspector-General of Insane, 9 Richmond Terrace, Domain; p.r. Cleveland-street, Wahroonga.
1893		Sinclair, Russell, M. I. Mech. E., etc., Consulting Engineer, Vickery's Chambers, 82 Pitt-street.
1891	P 3	Smail, J. M., M. Inst. C.E., Chief Engineer, Metropolitan Board of Water Supply and Sewerage, 341 Pitt-street.
1904	P 1	*Smail, Herbert Stuart Inglis, B.E. *Syd.*, Bagan Serai, Federated Malay States.
1893	P 31	Smith, Henry G., F.C.S., Assistant Curator, Technological Museum, Sydney.
1874	P 1	‡Smith, John McGarvie, 89 Denison-street, Woollahra.
1899		Smith, R. Greig, D. Sc. *Edin.*, M. Sc. *Dun.*, Macleay Bacteriologist, 'Otterburn,' Double Bay.
1886		Smith, Walter Alexander, M Inst. C.E., Roads, Bridges and Sewerage Branch, Public Works Department; 12A Phillip-st.
1896		Spencer, Walter, M.D. *Brux.*, 13 Edgeware Road, Enmore.
1904		Stanley, Henry Charles, M. Inst. C.E., Royal Chambers, Hunter and Castlereagh-streets.
1892	P 1	Statham, Edwyn Joseph, Assoc. M. Inst. C.E., Cumberland Heights, Parramatta.
1900		Stewart, J. D., M.R.C.V.S., Government Veterinary Surgeon, Department of Mines and Agriculture; p.r. Cowper-street, Randwick.
1903		Stoddart, Rev. A. G., The Rectory, Manly.
1883	P 3	Stuart, T. P. Anderson, M.D., LL.D. *Edin*, Professor of Physiology, University of Sydney; p.r. 'Lincluden,' Fairfax Road, Double Bay.
1901	P 1	Süssmilch, C. A., Technical College, Sydney.
1905		Taylor, John M., M.A., LL.B. *Syd.*, 'Eastbourne,' Alfred-street, North Sydney.
1893		‡Taylor, James, B. Sc., A.R.S.M., Nymagee.
1899		Teece, R., F.I.A., F.F.A., General Manager and Actuary, A.M.P. Society, 87 Pitt-street.
1861	P 19	Tebbutt, John, F.R.A.S., Private Observatory, The Peninsula, Windsor, New South Wales.
1896		Thom, James Campbell, Solicitor, 'Dunoon,' Eurella-street, Burwood.
1896		Thom, John Stuart, Solicitor, Athenæum Chambers, 11 Castlereagh-street.
1878		Thomas, F. J., Newcastle and Hunter River Steamship Co., 147 Sussex-street.
1879		Thomson, Dugald, M.H.R., 'Wyreepi,' Milson's Point.

Elected		
1885	P 2	Thompson, John Ashburton, M.D. *Brux.*, D.P.H. *Cantab.*, M.R.C.S. *Eng.*, Health Department, Macquarie-street.
1896		Thompson, Capt. A. J. Onslow, Camden Park, Menangle.
1892		Thow, William, M. Inst. C.E., M. I. Mech. E., Locomotive Department, Eveleigh.
1894		Tidswell, Frank, M. B., M. Ch., D P.H. *Cantab.*, Health Department, Sydney.
1894		Tooth, Arthur W., Kent Brewery, 26 George-street, West.
1879		Trebeck, P. C., F. R. Met. Soc., 12 O'Connell-street.
1900		Turner, Basil W., A.R.S.M., F.C.S., Wood's Chambers, Moore-st.
1905		Turner, John William, Assistant Under Secretary, Department of Public Instruction, Sydney.
1883		Vause, Arthur John, M.B., C.M. *Edin.*, 'BayView House,' Tempe.
1884		Verde, Capitaine Felice, Ing. Cav., viâ Fazio 2, Spezia, Italy.
1890		Vicars, James, M.C.E., M. Inst. C.E, City Surveyor, Adelaide.
1892		Vickery, George B., 78 Pitt-street.
1903	P 1	Vonwiller, Oscar U., B. Sc., Demonstrator in Physics, University of Sydney.
1876		Voss, Houlton H., J.P., c/o Perpetual Trustee Company Ld., 2 Spring-street,
1904		Vogan, Harold Sebastian, Assoc. M. Inst. C.E.. Authorised Surveyor N.Z.,Chief Draftsman, Existing Railways N.S.W.,Bridge-st.
1898	P 1	Wade, Leslie A. B., Assoc. M. Inst. C.E. Department of Public Works
1879		Walker, H. O., Commercial Union Assurance Co., Pitt-street.
1899		‡Walker, Senator J. T., 'Rosemont,' Ocean-street, Woollahra.
1901		Walkom, A. J., A.M.I.E.E., Mem. Elec. Assoc. N.S.W., Electrical Branch, G.P.O. Sydney.
1900		Wallach, Bernhard, B.E. *Syd.*, Electrical Engineer, 'Oakwood,' Wardell Road, Dulwich Hill.
1891		Walsh, Henry Deane, B.E., T.C. *Dub.*, M. Inst. C.E., Engineer-in-Chief, Harbour Trust, Circular Quay.
1903		Walsh, Fred., George and Wynyard-streets ; p.r. 'Walworth,' Park Road, City E.
1901		Walton, R. H., F.C.S., 'Flinders,' Martin's Avenue, Bondi.
1898		Wark, William, 9 Macquarie Place ; p.r. Kurrajong Heights.
1877		Warren, William Edward, B.A., M.D., M. Ch., Queen's University *Irel.*, M.D. *Syd.*, 283 Elizabeth-street, Sydney.
1883	P 16	Warren, W. H., Wh. Sc., M. Inst. C.E., Professor of Engineering, University of Sydney. *Vice-President.*
1876		Watkins, John Leo, B.A. *Cantab.*, M.A. *Syd.*, Parliamentary Draftsman. Attorney General's Department, Macquarie-st.
1876		Watson, C. Russell, M.R.C.S. *Eng.*, 'Woodbine,' Erskineville Road, Newtown.
1897		Webb, Frederick William, C.M.G., J.P., 'Livadia,' Manly.
1903		Webb, A. C. F., Consulting Electrical Engineer, Vickery's Chambers, 82 Pitt-street.
1892		Webster, James Philip, Assoc. M. Inst. C.E., L.S., *New Zealand*, Town Hall, Sydney.
1867		Weigall, Albert Bythesea, B.A. *Oxon.*, M.A. *Syd.*, Head Master, Sydney Grammar School, College-street.

Elected		
1902		Welsh, David Arthur, M.D., M.A., B.Sc., Professor of Pathology, Sydney University, Glebe.
1881		‡Wesley, W. H.
1879		‡Whitfeld, Lewis, M.A. *Syd.*, 'Glencoe,' Lower Forth-street, Woollahra.
1892		White, Harold Pogson, F.C.S., Assistant Assayer and Analyst, Department of Mines; p.r. 'Quantox,' Park Road, Auburn.
1877		‡White, Rev. W. Moore, A.M., LL.D., T.C.D.
1883		Wilkinson, W. Camac, M.D. *Lond.*, M.R.C.P. *Lond.*, M.R.C.S. *Eng.*, 218 Macquarie-street.
1876		Williams, Percy Edward, Comptroller, Government Savings Bank, Sydney.
1901		Willmot, Thomas, J.P., Toongabbie.
1878		Wilshire, James Thompson, F.R.H.S., J.P., 'Coolooli,' Bennet Road, Neutral Bay.
1879		Wilshire, F. R., Police Magistrate, Penrith.
1890		Wilson, James T., M.B., Master Surgeon, *Edin.*, Professor of Anatomy, University of Sydney.
1873		Wood, Harrie, J.P., 10 Bligh-st.; p.r. 54 Darlinghurst Road.
1891		Wood, Percy Moore, L.R.C.P. *Lond.*, M.R.C.S. *Eng.*, 'Redcliffe,' Liverpool Road, Ashfield.
1876	P 1	Woolrych, F. B. W., 'Verner,' Grosvenor-street, Croydon.
1902		Wright, John Robinson, Lecturer in Art, Technical College, Harris-street, Sydney.
1879		Young, John, 'Kentville,' Johnston-street, Leichhardt.

Honorary Members.

Limited to Thirty.

M.—Recipients of the Clarke Medal.

1901		Baker, Sir Benjamin, K.C.M.G., D.Sc., LL.D., F.R.S., etc., 2 Queen Square Place, London, S.W.
1875		Bernays, Lewis A., C.M.G., F.L.S., Brisbane.
1905		Cannizzaro, Stanislao, Professor of Chemistry, Reale Università Rome.
1900		Crookes, Sir William, F.R.S., 7 Kensington Park Gardens, London W.
1875	M	Ellery, Robert L. J., F.R.S., F.R.A.S., c/o Government Astronomer of Victoria, Melbourne.
1905		Fischer, Emil, Professor of Chemistry, University, Berlin.
1887		Foster, Sir Michael, M.D., F.R.S., Professor of Physiology, University of Cambridge.
1875	P 1 M	Hector, Sir James, K.C.M.G., M.D., F.R.S., late Director of the Colonial Museum and Geological Survey of New Zealand, Wellington, N.Z.
1880	M	Hooker, Sir Joseph Dalton, K.C.S.I., M.D., C.B., F.R.S., &c., c/o Director of the Royal Gardens, Kew.
1892		Huggins, Sir William, K.C.B., D.C.L., LL.D., F.R.S., &c., 90 Upper Tulse Hill, London, S.W.
1901		Judd, J. W., C.B., F.R.S., F.G.S., Professor of Geology, Royal College of Science, London.

Elected		
1903		Kelvin, Right Hon. William Thomson, Lord, O.M., G.C.V.O., D.C.L., LL.D., F.R.S., etc., 15 Eaton Place, London, S.W.
1903		Lister, Right Hon. Joseph, Lord, O.M., B.A., M.B., F.R.C.S. D.C.L., F.R.S., etc., 12 Park Crescent, Portland Place, London, W.
1901		Newcomb, Professor Simon, LL.D., Ph. D., For. Mem. R.S. Lond., United States Navy, Washington.
1905		Oliver, Daniel, LL.D., F.R.S., Emeritus Professor of Botany, University College, London.
1894		Spencer, W. Baldwin, M.A., C.M.G., F.R.S., Professor of Biology, University of Melbourne.
1900	M	Thiselton-Dyer, Sir William Turner, K.C.M.G., C.I.E., M.A., B.Sc. F.R.S., F.L.S., Director, Royal Gardens, Kew.
1895		Wallace, Alfred Russel, D.C.L. *Oxon.*, LL.D. *Dublin*, F.R.S., Old Orchard, Broadstone, Wimborne, Dorset.

Obituary 1905.

Honorary Members.

1875		Gregory, The Hon. Sir Augustus Charles.
1888		Hutton, Captain Frederick Wollaston.

Ordinary Members.

1878		Dean, Alexander
1877		Hume, J. K.
1877		Keep, John
1856		Moore, Charles
1877		Perkins, Henry A.
1897		Portus, A. B.

AWARDS OF THE CLARKE MEDAL.

Established in memory of

The late Revd. W. B. CLARKE, M.A., F.R.S., F.G.S., &c.,

Vice-President from 1866 *to* 1878.

To be awarded from time to time for meritorious contributions to the Geology, Mineralogy, or Natural History of Australia.

1878 Professor Sir Richard Owen. K.C.B., F.R.S., Hampton Court.

1879 George Bentham, C.M.G., F.R.S., The Royal Gardens, Kew.

1880 Professor Thos. Huxley, F.R.S., The Royal School of Mines, London. 4 Marlborough Place, Abbey Road, N.W.

1881 Professor F. M'Coy, F.R.S., F.G.S., The University of Melbourne.

1882 Professor James Dwight Dana, LL.D., Yale College, New Haven, Conn., United States of America.

1883 Baron Ferdinand von Mueller, K.C.M.G., M.D., PH.D., F.R.S., F.L.S. Government Botanist, Melbourne.

1884 Alfred R. C. Selwyn, LL.D., F.R.S., F.G.S., Director of the Geological Survey of Canada, Ottawa.

1885 Sir Joseph Dalton Hooker, K.C.S.I., C.B., M.D., D.C.L., LL.D., &c., late Director of the Royal Gardens, Kew.

1886 Professor L. G. De Koninck, M.D., University of Liège, Belgium.

1887 Sir James Hector, K.C.M.G., M.D., F.R.S., Director of the Geological Survey of New Zealand, Wellington, N.Z.

1888 Rev. Julian E. Tenison-Woods, F.G.S., F.L.S., Sydney.

1889 Robert Lewis John Ellery, F.R.S., F.R.A.S., Government Astronomer of Victoria, Melbourne.

1890 George Bennett, M.D. Univ. *Glas.*, F.R.C.S. *Eng.*, F.L.S., F.Z.S., William Street, Sydney.

1891 Captain Frederick Wollaston Hutton, F.R.S., F.G.S., Curator, Canterbury Museum, Christchurch, New Zealand.

1892 Sir William Turner Thiselton Dyer, K.C.M.G., C.I.E., M.A., B.Sc., F.R.S., F.L.S., Director, Royal Gardens, Kew.

1893 Professor Ralph Tate, F.L.S., F.G.S., University, Adelaide, S.A.

1895 Robert Logan Jack, F.G.S., F.R.G.S., Government Geologist, Brisbane, Queensland.

1895 Robert Etheridge, Junr., Government Palæontologist, Curator of the Australian Museum, Sydney.

1896 Hon. Augustus Charles Gregory, C.M.G., M.L.C., F.R.G.S., Brisbane.

1900 Sir John Murray, Challenger Lodge, Wardie, Edinburgh.

1901 Edward John Eyre, Walreddon Manor, Tavistock, Devon, England.

1902 F. Manson Bailey, F.L.S., Colonial Botanist of Queensland, Brisbane.

1903 Alfred William Howitt, D. Sc. *Cantab.*, F.G.S., Hon. Fellow Anthropol. Inst. of Gt. Brit. and Irel., 'Eastwood,' Bairnsdale, Victoria.

AWARDS OF THE SOCIETY'S MEDAL AND MONEY PRIZE.

The Royal Society of New South Wales offers its Medal and Money Prize for the best communication (provided it be of sufficient merit) containing the results of original research or observation upon various subjects published annually.

Money Prize of £25.

1882 John Fraser, B.A., West Maitland, for paper on 'The Aborigines of New South Wales.'

1882 Andrew Ross, M.D., Molong, for paper on the 'Influence of the Australian climate and pastures upon the growth of wool.'

The Society's Bronze Medal and £25.

1884 W. E. Abbott, Wingen, for paper on 'Water supply in the Interior of New South Wales.'

1886 S. H. Cox, F.G.S., F.C.S., Sydney for paper on 'The Tin deposits of New South Wales.

1887 Jonathan Seaver, F.G.S., Sydney, for paper on 'Origin and mode of occurrence of gold-bearing veins and of the associated Minerals.

1888 Rev. J. E. Tenison-Woods, F.G.S., F.L.S., Sydney, for paper on 'The Anatomy and Life-history of Mollusca peculiar to Australia.'

1889 Thomas Whitelegge, F.R.M.S., Sydney, for 'List of the Marine and Fresh-water Invertebrate Fauna of Port Jackson and Neighbourhood.

1889 Rev. John Mathew, M.A., Coburg, Victoria, for paper on 'The Australian Aborigines.

1891 Rev. J. Milne Curran, F.G.S., Sydney, for paper on 'The Microscopic Structure of Australian Rocks.'

1892 Alexander G. Hamilton, Public School, Mount Kembla, for paper on 'The effect which settlement in Australia has produced upon Indigenous Vegetation.'

1894 J. V. De Coque, Sydney, for paper on the 'Timbers of New South Wales.'

1894 R. H. Mathews, L.S., Parramatta, for paper on 'The Aboriginal Rock Carvings and Paintings in New South Wales.'

1895 C. J. Martin, B.Sc., M.B. *Lond.*, Sydney, for paper on 'The physiological action of the venom of the Australian black snake (*Pseudechis porphyriacus*).'

1896 Rev. J. Milne Curran, Sydney, for paper on 'The occurrence of Precious Stones in New South Wales, with a description of the Deposits in which they are found.'

PRESIDENTIAL ADDRESS.

By C. O. BURGE, M. Inst. C.E., Telford Medallist, Inst. C.E.

[*Read before the Royal Society of N. S. Wales, December 7, 1904.*]

As to the main subject of my address, I have been confronted with the usual difficulty of choosing it. Ordinarily, the annual address has been either a resumé, during a definite period, of the work of science generally, or of that section of it with which the avocations of the particular president befits him best to deal. The first method necessarily involves a good deal of second hand information, given by one who is necessarily not an expert in all, and as it is, of course, a large subject, dealt with in a comparatively small space, it must be scrappy and unsatisfactory. Such a treatment of the subject would be like the discharge from an ancient bell mouthed blunderbuss, which scatters all round, but hits nobody very effectively. The alternative of dealing with the president's own speciality may be compared to the bullet from the modern rifle, which deals with one object effectively, but leaves the rest untouched. Such special subjects had best be left to the annual addresses of the chairmen of the Sections of this Society, which its hospitable policy throws open to all branches of science.

Between this Scylla and Charybdis, however, there is a middle course, which, unlike such generally, is not a weak one, owing to two recent facts to which I shall presently refer. The subject I have chosen is the connexion between Engineering and Science, as a whole, and the two facts just mentioned which have brought this connexion into prominence, are firstly, the establishment of examinations in scientific subjects, by the Institution of Civil Engineers, as a condition of entry, and secondly, the cordial recognition

by this Society, which is the chief and oldest representative of science in Australasia, of engineering as one of its branches, emphasized by the fact of the election to the high office of President, of two engineers previously, and now a third, in my own person.

In the earlier ages, we may surmise, that the connexion, which is the subject of this address, was closer than in later times, for though, as regards the great ancient engineering works now extant in Egypt, and throughout the Roman Empire, the names of the designers are, to a large extent lost, we may yet be fairly sure that, it being before the age of specialism, the science of engineering, necessary for those monuments of human skill, were concentrated in the same individuals. As scientists whose theories helped engineering in the classic period, might be mentioned Thales, Anaxagoras, Ptolemy, Euclid, Hipparchus, Appolonius, but above all, Archimedes.

After the work of the Ancients, we find that of the Moors of Spain, prominent in this connection, as illustrated by the survival of several scientific terms such as algebra and chemistry, which are Arabic in origin. Leonardo da Vinci, whose fame as an artist makes us forget that he was also a scientist and engineer, treated of the laws of motion, before the end of the 15th century, though his works were not printed till 100 years later. Euclid was translated from the Greek early in the 16th century, and Cardan and Tartaglia, in the same age, became the founders of the higher algebra. An Englishman, Robert Record, invented, in 1557, the signs since used for plus and minus, and the two parallel horizontal lines for equality, and though this seems to us a small thing, we must remember that facilities of this sort were no trifles, in the birth of the science.

Astronomy, in its help to geodesy, has had much to do with engineering, so that Copernicus can hardly be left out

in a summary of this kind, nor can we forget Tycho Brahe in his self exile for 20 years, in his lonely Baltic isle, and his observations there, unassisted as he was, by modern telescopes.

Cardan and Tartaglia, already mentioned, as well as Ubaldi, may be said to have created the science of mechanics, which has, more than any other, helped engineering, while the great name of Galileo, who for versatility of genius, is one of the greatest of human names, advanced it largely by his experiments in statics and dynamics, and in the invention of the telescope. It was finely said of him, at the time, that by this feat, he had seen more than all the eyes that had gone before, and had opened the eyes of all that were to come after him.

Hydrostatics, which, with hydraulics, governs the operations of water supply and sewerage engineering, and in which no advance had been made since the time of Archimedes, was investigated in the same century by Stivinius, and from William Gilbert, an Englishman of Queen Elizabeth's reign, we have a Latin treatise on the magnet, in which the dawn of electrical science is dimly perceived, and in which so little was done, since, up to the middle of the last century.

But all this had no interest for the constructing engineers, or mechanics, as they were then called, of that time. The great rule of thumb reigned supreme and undisputed. Francis Bacon, in his *Filum labyrinthi*, wrote, "The mechanics take small light from natural philosophy, and do but spin on their own little threads," and the reproach, in which his far-seeing intellect is well shewn, might have been justified for many generations after him.

James Watt, notably, and some others in the early days of modern engineering, did, undoubtedly, bring the dim lamp of the science of their day to light up their work, but

many ignorant men relied on their native wit, and practical experience, to achieve results which, though wonderful, as operations in the dark, would have been so much better, if their earlier training had led them to ask for the illuminating aid of science.

Many a laborious scientific investigation of the present day, is looked upon as only abstractedly interesting, and of no practical advantage outside the walls of an institution like this in which we meet, and it is thought that money spent upon it is taken from some more practical immediate use. So said the so-called practical men of 300 years ago. Now we know how grievously they were mistaken, and how the Merry Monarch, who is said to have never said a foolish thing, nor done a wise one, certainly did a wise thing, in founding our great parent, the Royal Society of London, to which is due so much of the practical science of the last two centuries.

The Elizabethan mechanics knew not of their great contemporary Napier of Merchistoun, who, by his invention of logarithms, has so greatly lightened the labours, not only of the astronomer and through him, the navigation of the world, but also those of the engineering designer. Indeed without Napier's aid, the vast work of these callings, at the present day, would be impossible. Though hinted at by an earlier German writer, Michael Stifelius, this invention of the 17th century was undoubtedly one of the greatest intellectual feats of the human mind, and it is remarkable in having issued complete, like the birth of Pallas Athene, ready armed and equipped, from the author's brain, and it has not received any material improvement since. Nor were the mechanics and millwrights of succeeding generations more aware of the scientific achievements, affecting their work, of Kepler, Galileo, Cavalieri, Harriott, Descartes, Newton and others, in conic sections, algebra and mensur-

ation, as well as in statics and dynamics. Later, it was due solely to the conceptions of Joseph Black, chemist, physician, and professor, in Glasgow and Edinburgh, as to the action of pressure on boiling point, and absorption of heat by vapour, that James Watt was enabled to effect a revolution in the construction of the steam engine.

Pambour, Eaton Hodgkinson, Clerk Maxwell, Kelvin, and Lodge, with many others, have more recently contributed to the achievements of the engineer.

In the last half of the century just passed, however, the tendency of the education of the engineer being undertaken by technical institutions, rather than by the older pupilage system, has, so to say, married engineering to science. It has been truly a marriage at a mature age, but now that the parties to it are old enough to know their own minds, surely it is a love match, which is being blessed with an ample progeny.

The Odyssey of Homer is considered by some authorities to have been written solely as an allegory of man's life through this world of temptations and dangers, and of his protection from them by the heavenly powers. The tale of the great hero Odysseus, in his temptations by Circe and Calypso, his struggles with the monster Polyphemus, and the loosening of the windbag of Æolus, but ever helped by the divine influence of the goddess of Wisdom, to the arms of the faithful Penelope, personifies the life of every man, through his mortal existence here on earth. As to the windbag, we have in the present day, unlettered and small knowing souls, as Shakespeare calls them, who loosen on us many windbags, which waste our energies for real advancement, as the reporting columns of our newspapers shew, and who, one would almost think, were within the prophetic insight of old Homer when he composed the allegory. May we not take this wonderful story of old,

more vivid and entertaining than any novel written since, as an illustration of our subject. Odysseus, working onward to his goal, but, even though he is called the man of many devices, the engineer of his age, blindly falling into difficulties, often of his own making, nevertheless ever rescued and sustained by the fair goddess of all science, the grey eyed Athene.

The fairy tales of science may well be read for their own sweet sake, but when studied with a utilitarian end in view as in connexion with our subject, they have also their absorbing interest. Huxley's definition of science was "Organized Common Sense," but though true, this does not strike one as sufficiently distinctive, as this should describe other subjects with which science has nothing to do. The latter has one great distinction from those three other subjects which so largely employ the human mind, law, literature and art, that is the distinction of originality. Law is chiefly made up of precedents; listen to the finest poetry of modern times, and, in the ears of those who remember the ancient classics, familiar echoes are constantly ringing; in the great library of the British Museum and in the Bibliothèque Nationale of Paris, we see crowds of persons, called by courtesy, authors, constantly making new books out of old ones. These are the importers and retail tradesmen, not the producers of thought. A great Elizabethan writer speaks of books as "Ships passing through the vast seas of time, and making ages so distant, to participate of the wisdom, the one of the other." But he had only in view the classics of old, not those numerous worthless productions of to day which might be fitly compared to frail craft launched forth, to be wrecked on the shores of time, through their own weakness and instability. Greece and the middle ages have exhausted our ideas in art and architecture, and the invention of a new archi-

tectural style seems to be only a vision of despair—all is imitation, which though it may be the best flattery, is undoubtedly the confession of mediocrity. Not so in science. The galaxy of its brilliant originators still shine supreme in the great heaven of scientific discovery, and periodically there gleams from it some bright particular star, leading us to some epoch making achievement in the betterment, and in the progress, of mankind.

The discovery of the secrets of nature are generally individualistic, and lead to the laws of nature, laws which are interpreted by the scientist and regulated in their action, to benefit of mankind, by the surgeon, the navigator, but above all, by the engineer. The discoverer, the scientist, and the executant, this great trinity, is necessary for the physical well being of the world. In this music of the spheres, we must have the inventor of the principles of harmony, the composer to apply them, and the performer to delight our ears and our intellect.

The absolute necessity of the man of science to modern life, has recently been well illustrated by the production of an amusing comedy, where, among a party cast on a desert island, he, alone, who knows, is king. Rank, and worth in other respects, have to go under. The man who can, from his knowledge, create, he who holds command of the sources of material existence, he it is who leads the party; to rebel against him would mean misery and starvation. The greater part of the material, and not a little of the moral, progress of the world is due to the scientist and the engineer. They have lightened the tasks of life, and enabled men to find leisure from the drudgery of the mere struggle for existance. In the days of the spinning wheel, the hand-loom, and the carrier's waggon, the poor man's cottage was the scene of perpetual toil, even the small children had to work, with no time for

education or self improvement. It was only when the steam engine spread over sea and land, enabling one man to do the work of many, that mental and bodily comfort was attainable. It is the universal experience that, as machinery advances, not only wages, but the purchasing power of wages, rise, and with them the standards of life. A recent writer says that most people would resent it, as a bad joke, if told that the steam engine was the author of their being, and that they were more nearly related to it than to their uncles and aunts. Yet were it not for the machines worked by steam, probably more than half of us would never have existed.

Yet, among the young men of our day what are the names of Kelvin, of Lodge, of Rayleigh, of Dewar, and others, beside that of a famous cricketer, or of the man who can kick a ball further and straighter than another? We may allow that mental culture cannot stand alone, it must be the outcome of sufficient physical training. The old maxim "Mens sana in corpore sano," is ever true, but are we not overloading the latter part of the prescription? The traditional Irishman is sneered at for regarding fighting as an end, and not a means, but are not the Australians earning the reputation of confounding means and ends, in an even more absurd way? The combination is as old as Plato, who laid down music and gymnastics as the twin bases of education, the word Μουσικη, of course, including all art and literature, but the gymnastics were regarded as means only, for the double purpose of efficiency in war, and for the training of the body, so that it should be intellectually vigorous.

The man of science is unappreciated, because his gifts are unsought, and when conferred, are rapidly rendered commonplace by constant use, and often that use does not become available for some years after the invention has

left the author's brain. Till we get proper appreciation of scientific work, or are rudely awakened from self complacency by some crushing loss in trading, or in war, we shall not see the urgency of arming our citizens, in the great rivalry of nations, with better technical education. If the money spent on this in the British Empire were equal to that in Germany, we should hear no complaints of threatened loss of commercial supremacy. Professor Perry, indeed, recently proposed that £1,000,000 be granted by the British Government to encourage men of science to devote their energies to the increase of efficiency in the steam engine, and to the great economy of fuel, which forms so large a portion of the national assets, and if we could induce some foreign nations to dump down, on our shores, some of that common sense which guides them in such matters, it would be well for us here in Australia, as well at at home.

There is no doubt that we want more and better technical education in the Colonies. Progress has been made in this in Europe and America, and more especially in Germany, to which is probably owing the fact that, according to recent statistics, the original scientific papers published in that country, amount in number up to date, to 43% of the whole of those of the world. While the male population of Germany increased from 1870 to 1900, by 40%, the students at universities and technical colleges increased by 164%; but it is not the provision of educational means which is enough, we must have the desire to use them, as indicated by these German figures. It has been well said that the question is not whether a man has gone through the university, it is whether the university has gone through him. Training in habits of exact observation and intelligent inference is wanted, not that interest which is expressed by the observation of a man of unscientific temperament,

who once spoke of a proposition in Euclid, as a happy ending to a mildly exciting plot. At the same time, it must not be forgotten that technical education is for the selected few, not for all, and the selection is a matter of great importance. For the average child's skull is not, as some educationalists seem to think, constructed of india rubber, into which unlimited quantities of knowledge can be thrust. The Japanese understand this, in selecting boys from the lower schools, for the higher, and then again from the higher for special attention, either by sending them abroad at Government expense, or otherwise, and leaving the dull ones to be the hewers of wood and drawers of water.

One of the most curious features of scientific history is the fact that the Anglo Saxon race, in the Empire and in the United States, has been always preeminent in original invention, while, latterly, the Germans have been more assiduous and painstaking in that education, which brings out the value of the scientific progress, which the inventions of others produce, and the same is due of other branches of human thought. It was the English Francis Bacon that said "knowledge is power," but it is the German of to-day who most realizes and profits by that weighty and now obvious aphorism. It was the English Shakespeare who wrote the mightiest plays; it is at Berlin where they are chiefly acted and appreciated. When I was there recently, two of his plays were running, and at the same time in London, which is nearly three times as populous, there was not one.

Notwithstanding the neglect, until latterly, of science in engineering, great strides have been taken, perhaps the greatest, in recent times, have been in connexion with light; mechanical contrivances and energy, through the medium of electricity; and the disposal of the refuse of cities. As to light, there is a question which is more one

for the anatomist than the engineer, whether the human eye is developing the power to withstand, without injury, the intense brightness provided by modern electrical and gas engineers, for the aim seems to be, not the same light at less expense, but increased light even at increased expense. Some of the old and widely read books of 300 years ago, such as the first English Bibles, which must have been largely read by rushlights and without spectacles, are of such small print as to tax our eyes even now with this aid, and by modern lights. I remember, when I first visited Paris, nearly 40 years ago, one of the first impressions received was being almost dazzled by the brilliancy of the street lamps and shop lights, yet they consisted of the now despised dull yellow gas jets. In those days, spectacles on children were absolutely unknown.

Electricity has been said to be the most versatile and controllable means of conveying power yet discovered by man, and, in each phase of its activity, it represents an advance in the conquest of nature by means of its own laws, and by bending its forces to the improvement of all conditions of life. What that advance has been, is shewn by the fact that in the United Kingdom in 1896, 1901, and 1903, there were sold respectively 30, 110, and 345 millions of B.T. units, all this being due, primarily, to the scientists, from the humble beginnings of the Elizabethan William Gilbert, to the brilliant but more specialized men of the present age.

Chemical welding is a notable instance of quite recent adoption, where science has had the chief part, in an engineering contrivance of great value and widespread use.

The compounding of steam engines, and the improvements in the turbine, have gone a long way towards economy in mechanical power, where they are applicable, and especially in the latter, in reducing weight and vibration, as well as superintendence.

In gas engineering, both as regards light, heat, and power, the Welsbach and Mond systems have shewn what may be done by healthy rivalry.

The improved treatment of sewage of late years, in conjunction with bacteriology, has no doubt saved an enormous number of lives, valuable, and otherwise. Then the analyst has rendered incalculable service to the engineer, in investigating the properties of materials, and in the adjustment of them to the requirements of his art—quite a modern combination.

In this summary, and it would be the same, if treating of literature, one thing strikes us, that is when we consider the slight foundations on which they had to build, that the great men of old stand high in the background of the mental landscape of the past, while the foreground of the present is comparatively paltry and insignificant. It would seem as if nature had furnished a constant average amount of original intellect, in equal periods of time, and that, though population increases largely, that great gift does not increase with it, but is, through education, spread over a larger number of individuals, tending, in the far future, to a hopeless and uninteresting universal mediocrity. In this future democracy of brains, one man will, intellectually, be no better than another. Plato is said to have made havoc among our originalities, but without going so far as this, we may allow that the subtle fluid of original genius is gradually becoming rarified into a sort of cerebral hydrogen, so to say, in its enormous distribution. To this is due, that, in the later sciences, electricity for example, we can point to few great outstanding figures. Invention has been piecemeal.

So much for the past. Now for the future. Carlyle truly says:—"The man who cannot wonder, were he President of innumerable Royal Societies, and carried the whole

"Mécanique Céleste," and "Hegel's Philosophy," and the epitome of all laboratories and observatories, with their results, in his single head, is but a pair of spectacles, behind which there is no eye." Let me not, as one of those presidents, come under this withering condemnation, but proceed to wonder what will come next, as the fruits of science and engineering, no matter how unsuccessful I may be. The field is great, the secrets of nature, still to be solved, are inexhaustible, an ever larger and larger number of fertile brains are continuously at work, in discovery and invention, as the various patent offices shew; and these fresh brains start from an ever widening vantage ground of accumulated research and experience, which was absent in a great measure, as a support, to the giants of science and engineering of the old time.

First in importance, perhaps, though owing to practical difficulties, still far off, is the conversion of the working of our main line railways to traction by means of electricity, in which great force of nature, the physicist has inspired the engineer. In this application of it, it is to be hoped that the initial mistake of placing power houses in wrong sites will be avoided. It is well to remember that the electric fluid can be conveyed cheaper than coal, within limits, so that the power should originate near the coal mine. The old proverb, of the uselessness of sending coals to Newcastle, must take the form, rather, of the waste of carrying them away from such great sources of supply. Electricity, applied to long distance railway traffic, may also relieve us of the waste now going on, by which over 200 tons of train are moved, in order to carry 2 or 3 tons of passengers. Greater separation must also be made between express train service, and that of the slower passenger and goods. It was stated recently that, on the Midland Railway of England, a large proportion of the

14,000,000 annual train miles of shunting, was incurred to clear the line for expresses. Hence we may expect to see, as the first development, the establishment of special lines, more or less parallel to the existing main ones, for fast traffic only, worked by the latest electrical methods. As to suburban traffic, the nature of the new means of power, points to the adoption of uniform short intervals between trains, all day, the variation in traffic being met by increasing and diminishing the number of cars in each of the trains rather than their frequency, most of the cars being self-propelling. The enormous amount of the rolling stock, which would be rendered useless by the change to electricity is certain to be a great obstacle to it, and as this will make the change gradual, the evils of piecemeal installation can hardly be avoided.

It may not be generally known that, as far back as in the book of Job, Chap. xxxviii., v. 35, we have an allusion to wireless telegraphy. This is now, after so many ages, an accomplished fact, but there are also now promises of the most wonderful character, through the investigations of Tesla and others, as to the transmission, by electricity without wires, of power, the possibilities of which it is difficult to foresee. That, by the mysterious power of an intangible and invisible agency, great machinery, thousands of miles away, can be driven without visible connexion, is stimulating to the imagination in the highest degree. We seem to be peeping into the coming wireless age, when man will be, more and more, Lord of the Creation, and when the vassals of his intellect will come, at his beck and call, to provide for wants and comforts, hitherto either unknown, or furnished by the bodily toil of his fellow man.

Next, it is almost certain that the adoption of wide and straight streets in large cities, will be a work of the future, even at the cost of much reconstruction, so as to enable

the tram and motor car to expel altogether the more costly horse, which is slow and dirty. In crowded London, the omnibus and its horses scarcely utilize half the space they occupy, and it takes 50 minutes to crawl from the nearest residential parts, to the city. By combined extra speed and economy of space, the same business could be done by electric tram cars and motor cars, at much less cost and crowding if the streets were suitable. The horses in our streets are a continual offence to sanitation, and cause great expense in street maintenance, which would largely disappear if traffic were mechanical only, altogether independently of the great reduction in the cost of traction, for the same results. It is to be hoped that, in fixing the site for the Commonwealth city, within the Federal area, due attention will be given to the importance of level ground, which bears so much on this matter.

In an earlier part of this address, allusion was made to a proposal, that a million of money should be an endowment of research, as regards increased economy in dealing with the application of heat to mechanical power. It is humiliating to reflect on what a small percentage of the energy of fuel reaches its ultimate work, or what is called the Brake Horse Power. The turbine, and various forms of internal combustion engines, show better results than the ordinary reciprocating steam engines, and, as it is never too late to mend, and always too soon to despair, we may look to the science of the future, to save our rapidly diminishing fuel supply, in this matter.

It may be thought that the application of the various means of mechanical power to such an apparently insignificant matter as domestic service, is beneath the dignity of science or engineering, but when we consider how many families keep, at least, one servant, who might be doing useful work elsewhere, the question becomes more impor-

tant. There is no doubt that from £30 to £100 and over, per annum, in each family, making an enormous sum in the total, might be saved by the invention of machinery to do a considerable part of domestic work. Health also is concerned, as, for instance, in the general use of pneumatic dusters, by which dust, including all sorts of wicked germs, is completely removed, instead of, as at present, being lightly wafted from one resting place to another in the same room. Hitherto, domestic work, large in the aggregate, has been too much divided into small areas of action, to make the application of existing methods of mechanical power suitable, but, with the convenient electrical energy laid on, like water or gas, this objection will be got over. The cry of so many persons being thrown out of employment thereby, may be disregarded. The great engineering works and factories, of the present age superseded the local millwrights of 100 years ago, and the locomotive drove out the teamster, without ultimate harm to any class of worker, so we need not fear the consequences in this particular case, as the substitution, like others of the kind, would be gradual.

Again, we may possibly look for another fruit of the connexion between science and engineering, in the direct utilization for mechanical power of the sun's rays, by some more effective means of concentration than has hitherto been tried. We know, of course, that the sun's heat in past geological ages, is now producing practically all our power, chiefly through the instrumentality of coal, but coal is not inexhaustible, and it has to be mined. Experiments have been made in this direction in South Africa and elsewhere, but though the fuel cost nothing, the expense of the installation has been so large in proportion to the power obtained, that no practical success has been achieved. Here in New South Wales, we would willingly spare a good

deal of our summer heat, to any enterprising syndicate, if they could make use of it. At present, in such countries, the sun's rays are actually a source of waste in some ways, as our perspiring bodies and languid minds, at some periods of the year, sufficiently show. It is very difficult to conceive how this enormous dissipation of energy is to be prevented, but the concentration of potential energy existing in recently discovered substances, may give us hope.

The moon has hitherto been useless to all, except to poets, beyond its occasional light; for its action on tides is as often an impediment as a help to navigation, but could the oft talked of utilization of the rise and fall of the tide, for mechanical power, be made economically available, much of our fuel would be saved.

As far as I know, not much seems to have been done in in the direction of reducing skin friction in ships, though Froude, Sir William White, and others, have made it the subject of their investigations. There is not a word of any attempt to deal with the problem in the exhaustive historical address of Sir William White to the Institution of Civil Engineers last year. Yet the quantity of fuel consumed, in overcoming this resistance, must be enormous, in the great Atlantic liners of the day. And the worst of it is that, as we go on increasing size, we go on, simultaneously, piling up greatly increased skin friction, due to the larger surface and enhanced speed. Might not that important branch of science, curiously called natural history, help us in solving this problem? Observations could be made on the scales of certain fishes, whose speed, in proportion to their propelling power, is far greater than that of the fastest ocean steamer, in order to see how their skin friction has been reduced by natural selection. Long ages of quickness in seizing their prey, and in constant escape from their numerous enemies, must have developed a very efficient

minimum of skin resistance. It is a large subject, with room for great possibilities.

Akin to friction by water, is the resistance of air. Knowledge on this has been much advanced by experiments on the Berlin electric express train trials, on the performance of which I was enabled to give the Society some information in two recent papers. The velocity of the cars, up to 130 miles an hour, is the greatest ever reached by any conveyance, and afforded an unusual opportunity of measuring air resistance, which was fully availed of. Some of the ocean liners, of the present day, have an exposed cross section of over 3,000 square feet, and, when steaming at 23 knots, each pound of air pressure per square foot, on this surface, will absorb over 200 horse power to overcome the resistance offered. The consideration of such facts as these, in connexion with the results obtained on the German train experiments, we may hope will lead to enquiry, as to the best means of coping with this serious impediment to economical speed, on sea and land.

The dispersion of smoke and fog, neither of which however trouble us much in Australia, is a pressing question in some of the older countries, and electricity has been brought into successful requisition for this purpose, in experimental form. It has been estimated that a bad fog in London may cost £5,000 a day for artificial light alone, so that the importance of this question of the future is undoubted. The difficulty lies in the great quantities of electricity to be applied.

As regards the change in the physical qualities of metals used for constructive purposes, especially through what is called fatigue, we are looking for more information from physicists. We owe much to the experiments of Wöhler and Bauschinger, some years ago, but much remains to be discovered. Railway axles, marine shafts, and other

material subjected to constantly varying stresses, bending, torsional, etc., especially require investigation, as to what change of structure is produced by fatigue of this character, and if made, a great scientific and engineering gain would be brought about. Professor Arnold, who has designed a special testing apparatus, gave some interesting particulars on this matter, at the recent meeting of the British Association, when he said the subject was a much more complicated one than was generally supposed.

Great things are expected of single phase electrical working in traction. The difficulties which have hitherto attended this method are being successfully overcome, especially in America, and two lines, Fort Wayne to Springfield, and another in the same State, are being equipped on this system, and favourable results, as regards economy in first cost and working, are confidently expected. The direct current system, hitherto so largely used in such work, has its limitations, in voltage, speed control, etc., and by the alternating current, transforming properties can be brought into use, while the further adoption of the single phase working reduces the first cost, by its requirement of only one conducting wire.

I spoke of the necessity of wonder, for the man of science. One of the most beautiful things in nature is the wondering and wistful look, in the eyes of a child, gazing at the strange things in the glorious world into which it has been brought. By continual questioning, it gradually acquires knowledge of the outward semblances of the earth and sky, the trees and flowers, and their uses to him. To the true scientist, must be given this reverent wonderment, this constant enquiry, in fact, the spirit of a little child, if he is to coax from the great powers of nature, their inmost secrets, and use them, by the aid of his fellow worker the engineer, for the happiness, the well being, and the comfort of his fellow man.

Roll of Members.—The nnmber of members on the Roll on the 30th April, 1904 was 347. During the past year 19 members were elected; the deaths numbered 6, resignations 16, and 8 members were struck off the Roll for non-payment of their subscriptions, leaving a total of 336 to date. The following is a list of members who have died during the year:—

Allworth, J. Witter; elected 1885.
Dean, Alexander; elected 1878.
Gipps, F. B.; elected 1876.
King, Hon. Philip Gidley; elected 1874.
Mackenzie, Rev. P. F.; elected 1876.
Trebeck, P. N.; elected 1873.

Financial Position.—It is with regret we have to announce that for the first time since receiving a subsidy from the Government of N. S. Wales in 1877, the amount has been reduced by one half, *e.g.*, from £500 to £250. This is due to the very straitened condition of the finances of the State. The sudden withdrawal, without notice, of this amount has necessarily placed the Society in a very difficult position, so much so, that instead of being able to discharge its engagements as heretofore, the Society finds itself in the position of having to commence the new session with outstanding accounts to the amount of £125 2s. 1d. To carry on its work at all will necessitate the exercise of the most rigid economy; to cope with the difficulty will not be easy, and in any case the efficiency of the Society's work will be seriously impaired.

Library.—From the Hon. Treasurer's balance sheet it will be seen that during the past year the sum of £54 3s. 3d. was expended on books and periodicals; the binding amounted to £3 19s. 6d. The large and increasing number of periodicals that remain unbound is a matter of urgent need, affecting the convenience of members consulting the library and causing great waste of time to the Librarian.

When funds are available the Council intend to adopt a cheaper style of binding than formerly and will thus minimise the difficulty.

Exchanges.—The number of kindred institutions at present on the exchange list to whom copies of the Society's Journal and Proceedings are sent is 433. The following publications were received last year in return:—375 volumes, 1,873 parts, 116 reports, 222 pamphlets, 2 maps, and 1 engraving, total 2,589. This includes a complete set of the Transactions of the American Society of Mechanical Engineers, Vols. I. to XXIV., 1880 to 1903.

Papers read in 1904.—During the past year the Society held nine meetings at which 15 papers were read, the average attendance of members was 36 and of visitors 3.

ART. I.—PRESIDENTIAL ADDRESS. By F. B. GUTHRIE, F.I.C., F.C.S., Chemist, Department of Agriculture, N.S.W.; Acting Professor of Chemistry, The University, Sydney.

ART. II.—On the absence of gum and the presence of a new diglucoside in the Kinos of the Eucalypts. By HENRY G. SMITH, F.C.S., Assistant Curator, Technological Museum, Sydney.

ART. III.—On some Natural Grafts between Indigenous Trees. By J. H. MAIDEN, F.L.S., Government Botanist and Director, Botanic Gardens. [*With Plates*]

ART. IV.—Possible Relation between Sunspots and Volcanic and Seismic Phenomena and Climate. By H. I. JENSEN, B.Sc., Junior Demonstrator in Chemistry and Geology, University of Sydney. (Communicated by Prof. T. W. E. DAVID, B.A., F.R.S., etc.)

ART. V.—On Eucalyptus Kinos, their value for Tinctures, and the non-gelatinization of the product of certain species. By HENRY G. SMITH, F.C.S., Assistant Curator, Technological Museum, Sydney.

ART. VI.—Notes on the Theory and Practice of Concrete-Iron Constructions. By F. M. GUMMOW, M.C.E. [*With Plates*]

ART. VII.—Current Papers, No. 8. By H. A. LENEHAN, F.R.A.S., Acting Government Astronomer. [*With Diagrams*]

ART. VIII.—Further Experiments on the Strength and Elasticity of Reinforced Concrete. By W. H. WARREN, Wh. Sc., M. Inst. C.E., M. Am. Soc. C.E., Challis Professor of Engineering.

ART. IX.—The Flood Silt of the Hunter and Hawkesbury Rivers. By Professor T. W. E. DAVID, B.A., F.G.S., F.R.S., and Acting Professor F. B. GUTHRIE, F.I.C., F.C.S.

ART. X.—Ethnological Notes on the Aboriginal Tribes of New South Wales and Victoria. By R. H. MATHEWS, L.S., Associé étranger Soc. d'Anthrop. de Paris; Corres. Memb. Anthrop. Soc., Washington, U.S.A., etc.

ART. XI.—Preliminary Observations on Radio-Activity and the Occurrence of Radium in Australian Minerals. By D. MAWSON, B.E., Junior Demonstrator in Chemistry, and T. H. LABY, Acting-Demonstrator in Chemistry in the University of Sydney.

ART. XII.—Pot Experiments to Determine the Limits of Endurance of different Farm-Crops for certain Injurious Substances. By F. B. GUTHRIE, F.I.C., F.C.S., and R. HELMS.

ART. XIII.—The Occurrence of Isolated Augite Crystals at the top of the Permo-Carboniferous Upper Marine Mudstones at Gerringong, New South Wales. By H. G. FOXALL. (Communicated by Prof. T. W. E. DAVID, B.A., F.G.S., F.R.S.)

ART. XIV.—The Approximate Colorimetric Estimation of Nickel and Cobalt in presence of one another. By R. W. CHALLINOR. (Communicated by Acting Professor J. A. SCHOFIELD, F.I.C., F.C.S., A.R.S.M.)

ART. XV.—Note on a Combined Wash-Bottle and Pipette. By J. W. HOGARTH. (Communicated by Acting Professor J. A. SCHOFIELD, F.I.C., F.C.S., A.R.S.M.)

Sections.—The Engineering Section held two Sessions at which three papers were read and discussed:—

ART. XVI.—Tacheometer Surveying with an Ordinary Theodolite. By THOMAS KENNEDY, Assoc. M. Inst. C.E.

ART. XVII.—Water Filtration. By J. M. SMAIL, M. Inst. C.E.

ART. XVIII.—Filtration of Water at the Hunter District Water Works, West Maitland. By J. B. HENSON, Assoc. M. Inst. C.E.

Lectures.—A course of five Popular Science Lectures was delivered during the Session 1904, which were well attended:—

June 23—The Distribution of Life in Australasia, by CHARLES HEDLEY, F.L.S.

July 28—The Fabric of the Universe, by Actg. Prof. G. H. KNIBBS, F.R.A.S.

September 22—The Solar System and Southern Sky, by H. A. LENEHAN, F.R.A.S.

October 27—The Steam Engine and its Modern Rivals, by S. H. BARRACLOUGH, B.E., M.M.E., Assoc. M. Inst. C.E.

November 24—The Nervous System in its genesis and development, by J. FROUDE FLASHMAN, M.D.

On the OCCURRENCE of CALCIUM OXALATE in the BARKS of the EUCALYPTS.

By Henry G. Smith, F.C.S., Assistant Curator, Technological Museum, Sydney.

[With Plate I.]

[*Read before the Royal Society of N. S. Wales, May 3, 1905.*]

The present inquiry is the outcome of an investigation of four West Australian Eucalyptus barks, to determine their value for tanning purposes. The results, which are published in the April number of the Agricultural Journal of that State, were from the following species:—"Salmon Gum" (*Eucalyptus salmonophloia*), "Gimlet" (*E. salubris*), "Mallet" (*E. occidentalis*), "White Gum" (*E. redunca*).

The results, particularly those from *E. salmonophloia* and from *E. salubris*, were such that it was considered desirable to proceed further, and it was thought that by investigating the barks of the Mallees of New South Wales, nformation might probably be obtained, not only as regards their tanning value, but which would also help towards elucidating some of the problems connected with these dwarf species of Eucalyptus, and which form such a pronounced feature in many parts of Australia.

The Eucalypts are, generally speaking, forest trees, and often reach large proportions both in height and in circumference, and the prevalence of these dwarf forms, which resemble other species in their morphological characters, is, therefore, somewhat remarkable, and the new facts which have been brought to light during this investigation may assist, perhaps, in their deeper study. The barks of the following Mallees, growing in New South Wales, were

investigated for the purpose of this inquiry:—"Grey Mallee" *(Eucalyptus Morrisi)*, "Water Mallee" *(E. oleosa)*, "Bull Mallee" *(E. dumosa)*, "Green Mallee" *(E. viridis)*, "Blue Mallee" *(E. polybractea)*, "Mallee" *(E. Behriana)*, "Mallee" *(E. gracilis)*, "Mallee" *(E. stricta)*. The various stages of the bark of the tall smooth barked tree, growing on the Blue Mountains, *Eucalyptus oreades*, were also examined.

When the powdered bark of *E. salmonophloia* was heated with water, white crystals separated in some quantity, of which a considerable amount floated on the top of the water. When boiled for some time the bark débris precipitated, and the crystals could then be removed with a spatula. They were collected in as pure a condition as possible, well washed and dried on a porous slab. Chemical determination showed them to consist of calcium oxalate. Under the microscope they were seen to be well defined monoclinic crystals, consisting principally of stout microscopic prisms. Many of the crystals were twinned, the twinning plane being, apparently, parallel to the basal plane, thus giving the twin a geniculate form. This form of twinning was very apparent with some species, as for instance, *E. polybractea*. The crystals polarised exceedingly well in bright colours. The bark of *E. salubris* gave an abundance of crystals identical in every respect with those obtained from *E. salmonophloia*, and the few crystals from *E. redunca* and from *E. occidentalis* were also identical. From all the barks of the New South Wales Mallees the same characteristic monoclinic crystals were obtained, and in form and appearance they were identical with those from the West Australian barks, with the exceptions that the crystals from *E. gracilis* were generally shorter and stouter, and those from *E. polybractea* were longer; in other respects they were the same. This form

of crystallised calcium oxalate seems, therefore, to be common to the barks of the Eucalypts, but while in some of these the calcium oxalate is present in great abundance, in other species it occurs only in very small amount, as in the bark of *E. Morrisi*, for instance. The mallees which contain the crystals in greatest abundance, seem to be those species which have a very thin smooth bark, or at most a little persistent bark at the base, this is shown with *E. Behriana*, *E. gracilis*, and *E. oleosa*. It does not follow, however, that the thin barks always contain calcium oxalate in abundance, because the barks of *E. stricta* and of *E. polybractea* are both thin and smooth, and contain but a small amount of that salt. In the thicker and more fibrous barks of *E. Morrisi* and *E. viridis* (the thin barks of these species were not determined) crystals were sparsely distributed.

Mr. S. J. Johnston of the Technological Museum has kindly measured crystals of various species, the mean results being as follows:—

General type,	length	0·01746 mm.	breadth	0·00776 mm.
E. gracilis	„	0·01552 „	„	0·01164 „
Ditto, prisms	„	0·0175 „	„	0·00679 „
E. polybractea	„	0·0291 „	„	0·00582 „

Mr. R. T. Baker, the Curator (to whom I am indebted for botanical assistance in preparing this paper) had already informed me that on botanical evidence of buds, fruit, leaves, and timber, he could distinguish no difference between *E. salmonophloia* of West Australia and *E. oleosa* of this State. Through the kindness of the authorities of West Australia, the leaves of *E. salmonophloia* were forwarded to the Museum for investigation, and the oil of this species was found to consist of the same constituents as had previously been obtained from *E. oleosa*, and allowing for rather more pinene in the oil of *E. salmonophloia*,

practically no difference could be determined between the oils of these two species, as they both consisted largely of eucalyptol and pinene, with an entire absence of phellandrene. The aldehyde aromadendral was present in both oils. The barks of the two species, however, differed considerably in thickness, but as will be shown later not in chemical constituents,[1] both were identical in this respect and the tannins were alike in both barks. But even with this close botanical similarity and chemical agreement between the constituents of the oils and the barks, it was difficult to understand why a forest tree like that of *E. salmonophloia* should degenerate into the stunted Mallee growth of *E. oleosa*. From the results now obtained it may be possible, perhaps, to offer a feasible suggestion as to the origin of this peculiarity, and there seems no reason to suppose that this alteration into the Mallee form is an isolated case. *E. salmonophloia* and *E. olcosa* being apparently the same tree in different forms of growth, it is probable that the latter is a stage in the slow and permanent degeneration of the larger tree. Although *E. oleosa* is generally seen as a stunted shrub, yet, it often occurs as a persistent tree, and even in New South Wales it is often found having a height of 40 to 50 feet, with a corresponding size of trunk. Mr. R. H. Cambage informs me that in his experience, *E. oleosa* is found in tree form more often than any other species of Mallee. In both *E. viridis* and in *E. Morrisi* trees are often found which have reached to a fair size, but the tendency to early decay appears to be marked in Eucalyptus species which most often take the Mallee form of growth.

It is generally accepted by physiologists that oxalic acid is poisonous to plants as well as to animals, and in Sachs'

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[1] This was also the case with the thin and the thick barks of the "Mallet" of West Australia, *E. occidentalis*.

p. 700, the following appears:—"The
n must, therefore, be sought partly in
icle for sulphuric and phosphoric acid
of food material, and partly in its fixing
which is poisonous to the plant, and renders
Dr. Sorauer says much the same in his
f Plants, Weiss' translation, page 33.

effer (Physiology of Plants, Ewart's translation
says, "as regards oxalic acid, its affinities,
s character, feeble heat of combustion, and the
ility of its calcium salt are all points to be taken
onsideration."

ich generally accepted conclusions must throw doubt
on the possibility of any particular species of Eucalyptus, r in fact of any other genus, to continue to form and dispose of such a large amount of oxalic acid without eventually suffering degeneration both in size and in robustness. In the bark of *Eucalyptus gracilis*, for instance, no less than 16·66% of the entire dried bark consisted of the particular form of calcium oxalate occurring in Eucalyptus barks, and some other species have been found to contain almost as much. If the theory advanced is a feasible one, and obtains support by further evidence, then *E. gracilis* is also the degenerate form of a larger tree. Perhaps this effect is due to the formation of oxalic acid at too rapid a rate to enable the tree to continue to use it without any ill effect, and other conditions be favourable, in the case of certain species, the result becomes apparent in the deposition of an increased amount of calcium oxalate in their barks, which eventually brings about this stunted form of growth.

It may be thought that the shedding of the bark by certain species of Eucalyptus is an effort to throw off this accumulation of calcium oxalate, but the investigation of

the three stages of the bark of one individual tree of *E. oreades* rather discounts this supposition, and suggests the idea that under ordinary conditions the Eucalypts use up the calcium oxalate first formed. Certainly it does not appear to be shed with the bark, and in this respect differs from trees which throw off with their leaves the calcium oxalate formed.

The following results show this clearly:—

(*a*) Fresh living bark 2 cm. thick;	calcium oxalate	=1·37%
(*b*) Thin ribbon bark 1 mm. thick;	„	=0·025%
(*c*) Thicker dead bark at base of trunk which was quite brown and 3 to 6 mm. thick;	„	nil

A smooth-bark tree was chosen because most of the Mallees have a smooth bark, or at most a little persistent bark at the base of the tree, or resemble the Boxes, and all have the general characteristics belonging to the larger trees of these classes. The Stringybarks do not appear to take on the Mallee form of growth, and some of the largest trees in Australia are species approaching this class.

That the solution from which the crystallised calcium oxalate was formed must have contained oxalic acid in excess, and thus be more or less poisonous, is indicated by the symmetrically formed crystals, and these crystals, too, belong to a form and have a constitution different from the calcium oxalate usually found in plants. The form peculiar to Eucalyptus barks contains one molecule of water, and has the composition and crystalline form of the mineral *Whewellite*, with which substance it is perhaps identical.

In the banana and other plants calcium oxalate occurs in needle-like crystals or raphides. In the root of the Turkey rhubarb, as well as in other plants, it occurs in crystals having a conglomerate form, and these are also found in some members of the cactus tribe, in *Phytolacca*

spp., in certain algæ and in other small plants. I cannot find, however, that crystallised calcium oxalate has previously been found occurring in quantity in the bark of plants belonging to genera which often occur as immense trees, and in this respect, therefore, the Eucalypts are peculiar. Crystals of carbonate of lime (crystoliths) have been found in the epidermis of some plants, as in a few species of Ficus, but the constituents of this salt are not considered to be poisonous.

The presence of calcium oxalate in quantity in Eucalyptus barks may eventually be found to have some bearing on the formation of the particular tannin present. It has already been determined that in those barks which contain much calcium oxalate the tannin is decidedly superior to that found in species in which the crystals are present only in small amount. Some of these barks should make excellent leather, and the amount of available tannin in some species is considerable. The bark of the "Gimlet," *Eucalyptus salubris*, for example, gave by extraction with hot water 30·5% of total extract, and 18·6% of tannin absorbed by hide powder; these were calculated on the air dried bark. The tannin extracts from this class of Eucalyptus barks do not readily decompose or even darken much when evaporated to dryness at the temperature of boiling water, and the manufacture of excellent tanning extracts from Eucalyptus barks is, therefore, possible.

The amount of calcium oxalate in the bark of *E. salubris* was 16%, and it should be possible to profitably extract this from the bark residue, and thus manufacture oxalic acid very cheaply as a by-product. The oxalic acid should also be obtained fairly pure at the first separation, because the other salts and organic substances precipitated at the same time in the alkaline solution, are readily dissolved by acetic acid. Eucalyptus barks rich in calcium oxalate are easily

ground to a fine powder, so that extraction should be practically complete.

The calcium oxalate.

The crystals which were removed from the surface of the water were almost white, and in appearance an impalpable powder. 0·1279 gram of air dried crystals suffered no loss when heated for two hours at 100 – 110° C., but when heated to constant weight at 170 – 180° C., they lost 0·0149 gram, equal to 11·65%; $C_2O_4Ca + H_2O$ contains 12·33% water; on igniting and fully carbonating the residue the calcium carbonate formed was 0·0835 gram. This shows that only one molecule of water was present, because with two molecules only 0·0779 gram could theoretically be obtained, and by the method of collecting, the crystals could not have been quite pure. No magnesia was detected.

The calcium oxalate was determined quantitatively in 4 grams of bark, ground as fine as possible. The barks were boiled with dilute hydrochloric acid, the filtrate made alkaline with ammonia and then acid with acetic acid. The precipitate was determined as calcium carbonate in the usual way. Volumetric determination with permanganate was not satisfactory.

The percentage amounts of calcium oxalate ($C_2O_4Ca + H_2O$) in the anhydrous barks of the several species was as follows. They are calculated from the calcium carbonate found. It is assumed that the whole of the calcium oxalate existed in the crystallised condition, the form and appearance of which can be seen from the micro-photograph attached, for which I am indebted to Mr. J. W. Tremain of the Technical College.

Following are the percentages of calcium oxalate :— *Eucalyptus gracilis* 16·66, *E. Behriana* 16·50, *E. salubris*, 16·00, *E. oleosa*, 10·64, *E. dumosa* 9·80, *E. salmonophloia*

8·34, *E. occidentalis* 6·82, *E. viridis* 5·01, *E. redunca* 4·46, *E. polybractea* 2·14, *E. stricta* 0·69, *E. Morrisi* 0·08.

The total amount of ash in the barks does not always correspond to the calcium oxalate present; for instance in *E. salubris* the total ash was 18·59%; in *E. gracilis* it was only 13·98%, of which amount 11·41% represents the calcium oxalate.

The general appearance and thickness of the several barks tested were as follows:—

Eucalyptus gracilis—a thin, mostly smooth bark, light in colour and not fibrous. Thickness 2 to 3 millimetres.

Eucalyptus Behriana—a very thin, smooth bark, light in colour, easily powdered and not fibrous. Average thickness 2 mm.

Eucalyptus salubris—a hard, thin, close, brittle bark, brownish to grey externally. Thickness 2 to 5 mm., but rarely more than 3 mm.

Eucalyptus oleosa—a somewhat thin and fibrous bark, separating in layers and of a light brown colour. Thickness from 3 to 5 mm.

Eucalyptus dumosa—a very thin, smooth bark, of a brownish to grey colour, powders easily. Thickness about 2 mm.

Eucalyptus salmonophloia—a thick, smooth bark, salmon to grey externally, somewhat hard and compact, but inclined to be fibrous, powders fairly well. Thickness from 7 mm. to 1 centimetre.

Eucalyptus occidentalis—a fairly light coloured bark and having layers of kino in the thicker portions, powders readily. Thickness from 5 mm. to 1 cm. (This bark also occurs much thinner, 2 to 4 mm.)

Eucalyptus viridis—a hard, compact bark but interlocked and fibrous; it was taken from a large tree. Externally

it had the general appearance of a "box" bark, and was somewhat dark coloured. Thickness about 1 cm.

Eucalyptus redunca—a somewhat thick bark, grey to brown externally with a yellowish fracture. It was quite brittle and fibrous, and not compact. Thickness from 7 mm. to 1 cm.

Eucalyptus polybractea—a thin, smooth bark, greenish externally, and in places coated with a brownish tissue-like coating. The thicker portion had a layer of kino. Thickness from 1 to 2 mm.

Eucalyptus stricta—a thin, smooth, somewhat fibrous bark, greenish externally. Thickness from 1 to 2 mm.

Eucalyptus Morrisi—a thick, fibrous bark, of a dull salmon colour right through, grey and scaly externally. This specimen was from a large tree, the thin bark not being procurable. Thickness from 1·5 cm. to 2 cm.

On SO-CALLED GOLD-COATED TEETH in SHEEP.

By A. Liversidge, LL.D., F.R.S.,
Professor of Chemistry, University of Sydney.

[*Read before the Royal Society of N. S. Wales, June 7, 1905.*]

Paragraphs have appeared recently in the newspapers stating that gold coated teeth have been found in sheep; and within the last week I received the lower half of a sheep's jaw bone from Mr. Charles G. Alford, the teeth of which are more or less completely incrusted with a yellow metallic looking substance, but more like iron pyrites (marcassite) or brass than gold. The incrustation is brittle and readily comes off in scales when even lightly scratched with the point of a penknife.

The surface of the tooth under the scale was found to be black, but apparently not decayed, for when the black coating is scraped off, the surface of the tooth is white; the thickness of the deposit does not apparently exceed the $\frac{1}{32}$ of an inch, or less than 1 mm. Only one tooth was scaled so as to destroy the specimen as little as possible. The scale partly dissolves in dilute acid. The residue consists of filmy organic matter, still possessing a metallic sheen although white in colour instead of yellow. When heated on platinum foil the scale blackens, partly fuses and leaves a white residue soluble in dilute hydrochloric and nitric acids. The residue contains phosphoric acid and apparently consists mainly of calcium phosphate. Under the microscope the scale is seen to be translucent and of a pale brownish colour, and under a half-inch objective it is seen to be made of thin layers, but there is no recognisable organic structure. The metallic lustre is due to the way in which the light is reflected from the surfaces of

the superimposed films. The incrustation on the teeth is apparently a deposit of tartar, and perhaps partly due to superficial decay of the tooth. I think similar coatings on sheeps' teeth have been recorded even in classical times, but I cannot recall a reference. It would be interesting to know whether this deposit on sheeps' teeth is common or not.

I also exhibit a calculus of a similar metallic looking character from a sheep's stomach, deposited in distinct layers round a piece of twig, but of rather a darker bronze tint than the substance on the teeth—this specimen belongs to the Sydney Technological Museum and was kindly lent by the Curator, Mr. R. T. Baker.

OBSERVATIONS ON THE ILLUSTRATIONS OF THE BANKS AND SOLANDER PLANTS.

By J. H. MAIDEN, Government Botanist and Director of Botanic Gardens, Sydney.

[*Read before the Royal Society of N. S. Wales, July 5, 1905.*]

THE issue of the third and final volume of the plates contemporaneously prepared by Banks' artists, is an event which assuredly demands the most marked emphasis that we Australians can give it. It is, to us at least, an important historical event. New South Wales was settled 17 years later as a consequence of Cook's voyage, and the

[1] "Illustrations of Australian plants collected in 1770 during Captain Cook's voyage round the world in H.M.S. "Endeavour," by the Right Honorable Sir Joseph Banks, Bart, K.B., P.R.S., and Dr. Daniel Solander, F.R.S., with determinations by James Britten, F.L.S., Senior Assistant, Department of Botany, British Museum, Part iii., 1905." [Part i., 1900; Part ii., 1901].

only place (Botany Bay—called by Cook Stingray Harbour) in modern New South Wales visited by the expedition is a suburb of Sydney. This voyage, therefore, has special interest for us, and it would be regrettable if the appearance of this work were ignored by Australian scientific men.

Through the good offices of Mr. Britten, the Trustees of the British Museum recently presented nearly 600 specimens collected by Banks and Solander to the National Herbarium, Sydney. Many of them are depicted in the work before us.

Mr. Britten's "Introduction" is very interesting. It describes what preparations had been made by Banks for an extensive work to be illustrated by many hundreds of plates and how the issue of it fell through, partly because of Solander's death in 1782 and partly on account of Banks' devotion to his duties as President of the Royal Society. Then follows some description of the various MSS connected with the voyage, including Solander's notes on "Plantæ Novæ Hollandiæ" which are in two volumes (small quarto) and are in the British Museum.

"The Australasian collections are represented by 412 sketches; from these 362 finished drawings were prepared, of which 340 were engraved. From the copper plates of these, the plates illustrating this volume have been lithographed; they represent 328 of the engravings, most of the remainder being unfinished or imperfect representations. Three of the drawings of which no plates exist—*Tribulus Solandri*, *Pleiogynium Solandri*, and *Myrmecodia Beccarii*—being of special interest, were drawn on stone by the late Robert Morgan, and raise the number of plants represented to 331."

That the copper plates of the present work should have remained in the British Museum unpublished for nearly 130 years is a remarkable occurrence, and shows how leisurely the progress of British science can be. While grateful for its belated appearance it seems difficult to believe that this most regrettable delay has been unavoidable.

The excellent illustrations are from contemporary copper-plates engraved from drawings executed by (*a*) Frederick Polydore Nodder, "Botanic painter to Queen Caroline" whose drawings date from 1777 – 1783; 173 drawings are from his pencil. (*b*) John Cleveley's drawings date from 1773 – 1775, and he is represented by 18 in the present work. (*c*) James Miller's drawings date from 1773 – 1775 and there are 47 of them. (*d*) John Frederick Miller's drawings were also executed from 1773 – 1775 and are 61 in number.

Useful notes are given of the engravers D. Mackenzie ("who probably did most of the work") and G. Sibelius. Information is given in regard to Mackenzie's other botanical work. But few of the plates are marked by the engraver's name. The value of the work is enhanced by the fact that it includes representations of many plants which have not been hitherto figured, so far as I am aware.

Mr. Britten gives for each plate a Latin description of each plant depicted (this is the work of Solander) also notes on the localities whence the specimens were obtained, and critical notes. We are informed that descriptions of other plants by Solander are extant, but only those are printed of which there are plates.

The work contains a reduction of Captain Cook's original chart of East Australian coast-line (1770), from originals in the British Museum. This is in a North Sheet and South Sheet. Also a chart of the coast-line of East Australia, as determined by recent surveys to 1890 (inserted for comparison with Cook's coast-line). Also a chart of New Zealand, explored in 1769 and 1770 by Lieutenant J. Cook, Commander of His Majesty's Bark "Endeavour," engraved by J. Bayly. These maps, which render reference to the localities whence Banks and Solander collected exceedingly

easy, are reproductions of those which were issued with Wharton's "Captain Cook's Journal" (1893).

In another place[1] I have given some notes on the synonymy adopted in this work, and herewith continue these observations:

No.	Name on Plate.	Name in *Flora Australiensis*.
251	*Myristica cimicifera* R.Br.	*M. insipida*, R.Br.

Bentham (and Mueller) unite *M. cimicifera* R.Br. and *M. insipida*, R.Br. under the name *M. cimicifera*. Britten maintains they are distinct species, so the name *M. insipida* should be added to the flora by the side of *M. cimicifera*.

No.	Name on Plate.	Name in *Flora Australiensis*.
253	*Atylus anethifolius*, O. Kuntze.	*Isopogon anethifolius*, Knight
254	" *anemonifolius*, O. Kuntze	" *anemonifolius*, Knight
256	*Linkia falcata*, O. Kuntze	*Personia falcata*, R.Br.
257	*Linkia lævis*, Cav.	*Personia lanceolata*, Andr. var. *lævis*

Bentham states that *Linkia lævis*, Cav. is syn. with *P. lanceolata*, var. *lævis*. Britten says it is identical with *P. salicina*, Pers. In my opinion the illustration is clearly *P. salicina*, Pers. and not *P. lanceolata* var. *lævis*, *unless they are both identical*. See full notes by Britten, and also by Bentham in "Flora Australiensis."

No.	Name on Plate.	Name in *Flora Australiensis*.
258	*Linkia lanceolata*, Britten	*Persoonia lanceolata*, Andr.
261	*Grevillea pteridifolia*, Knight	*Grevillea chrysodendron*, R.Br.
263	" *parallela*, Knight	" *polystachya*, R.Br.
264	" *glauca*, Knight	" *gibbosa*, R.Br.
268	*Isostylis ericifolia*, Britten	*Banksia ericifolia*, Linn. f.
269	" *integrifolia*, Britten	" *integrifolia*, Linn. f.
270	" *serrata*, Britten	" *serrata*, Linn. f.
271	" *dentata*, Britten	" *dentata*, Linn. f.
272	*Banksia cornucopiæ*, O. Kuntze	*Pimelea cornucopiæ*, Vahl.
273	" *linifolia*, O. Kuntze	" *linifolia*, Sm.
277	*Santalum oblongatum*, R.Br.	*Santalum lanceolatum*, R.Br.
296	*Omalanthus Leschenaultianus*, A. Juss.	*Carumbium populifolium*, Reinw.
303	*Hæmodorum corymbosum*, Vahl.	*Hæmodorum coccineum*, R.Br.
309	*Chlamysporum Banksii*, R.Br.	*Thysanotus tuberosus*, R.Br. var.
312	*Lomandra longifolia*, Labill.	*Xerotes longifolia*, R.Br.
313	" *multiflora*, Britten	" *multiflora*, R.Br.
314	" *filiformis*, Britten	" *filiformis*, R.Br.

The part includes figures of *Piper Betle*, Linn. and *Blephocarya involucrigera*, F.v.M., which are not in the *Flora Australiensis*. Figures of recently described plants

[1] Proc. Linn. Soc. N.S.W., 1903, pp. 711–716.

in the present part are *Petalostigma Banksii*, Britten and S. Moore, and *Eugenia Banksii*, Britten and S. Moore.

Some of the propositions of nomenclature gives us a shock. Our familiar *Banksia* is to be suppressed in favour of *Isostylis*. A new *Banksia* is to spring up from the ashes of the almost as familiar *Pimelea*. Our *Persoonias*, in every one's mouth, are to give way to *Linkia*; our *Isopogons* to *Atylus*. *Thysanotus* is to become *Chlamysporum*, while the well-known *Xerotes* is to be *Lomandra*. But the whole of the changes can only be understood by examination of those also proposed in Parts i. and ii.

As I write, the International Botanical Congress (adjourned from Paris, 1900) is meeting at Vienna, and, as the result of its deliberations, it is to be hoped that we shall have the authority of such an influential Congress for a settled nomenclature. When this Congress reports the names proposed in the present work will be passed in review.

Mr. Britten throughout the work, doubtless rightly, attributes to Banks and Solander plants for which in many instances Solander was originally quoted. He says:

"A careful study of the various memoranda and MSS preserved in the Department of Botany makes it clear that Banks, who had come to be regarded as a patron of science rather than as a man of scientific attainments, had much more botanical knowledge than was at one time supposed."

In conclusion, the publication of these fine folio volumes simply whets the appetites of Australians for more. We yearn for the publication of Solander's and Brown's manuscripts, and trust that they will not be kept back from any considerations of nomenclature of species. Such a reason, if advanced, seems to us inadequate in the case of priceless historical documents of the deepest interest to Australians. We would have liked our fathers to have had the privilege of seeing them; shall the privilege be denied to the living

and only be bestowed on a generation yet to be born? With all respect to the eminent specialists forming the scientific staff of the British Museum, we feel sure that these manuscripts must contain observations which can only be fully interpreted and appreciated by Australians.

THE REFRACTIVE INDICES, WITH OTHER DATA, OF THE OILS OF 118 SPECIES OF EUCALYPTUS.

By HENRY G. SMITH, F.C.S., Assistant Curator, Technological Museum, Sydney.

[Read before the Royal Society of N. S. Wales, August 2, 1905.]

THIS work has been undertaken to determine whether results of value could be obtained by the investigation of the physical constants of eucalyptus oils in this direction. The oils worked upon have—with a few exceptions, added under particular species for comparison—all been distilled at the Technological Museum, from material which was botanically investigated by my colleague Mr. R. T. Baker, F.L.S., before distillation. All the specimens were thus authentic and true to name. The whole of the oil contained in the leaves was distilled over as far as possible, and not the more volatile constituents only, which result can be largely accomplished by regulating the method and time of distillation. The richer commercial oils of *E. polybractea* under No. 22 have been thus obtained.

The general results, concerning most of this material, have already been published by Mr. Baker and myself in our work "Research on the Eucalypts and their Essential Oils," Sydney 1902, so that this paper may be considered

an addendum to that publication. Since that work was published the oils of many other species of Eucalyptus have been obtained, some of which were from West Australia; these are included here also.

In the Proceedings of the Royal Society of Victoria 1894, page 195, Mr. W. Percy Wilkinson records the refractive indices, and other data, of the oils of 18 species of Eucalyptus, several specimens of some of the species being determined. It is very probable, however, that a few were of doubtful origin, as they were obtained from various sources. The oil of *E. globulus*, if true to name, should hardly give so low a refractive index as there recorded with Nos. 36 and 46, which is almost that of eucalyptol itself; nor, should the oil be lævo-rotatory to the extent of 6·2 degrees. Again *E. pauciflora* (=*E. coriacea*) Nos. 28 and 60, contained no phellandrene. The oils of species having the leaf venation characteristic of *E. pauciflora* may reasonably be expected to contain phellandrene, and not to be dextro-rotatory to the extent recorded for No. 28. With undoubted species of Eucalyptus there is a marked agreement in chemical results within certain limits, not only with their oils but with their kinos.

It was thought advisable to determine the refractive indices, and the other necessary data, in the colder months of the year, so as to secure the least variation in temperature. During a large portion of the months of June and July the temperature of the laboratory did not vary more than half a degree from 16° C. either way. The specific gravities were mostly taken at the same time as the refractive indices, but where that was not done the slight correction necessary for 16° C. was made. The solubilities in 70% alcohol were also taken when the room temperature was at 16° C. The alcohol had a specific gravity 0·8722 at 15·5° C. and the method adopted was to transfer 2 cc. of

the oil to a dry test tube, using a narrow pipette, and then to run in 2 cc. of the alcohol from a burette, graduated in tenths, and afterwards by drops until the end was reached, agitating between each addition. The solubilities of the oils in alcohol are given in the previously mentioned work, but only in ½ volumes. The solubility results being of some value, this was not sufficiently delicate, so the more soluble oils were again determined. In no instance, with the crude oils, was solubility reached with an equal volume of 70% alcohol. For the more insoluble oils the previously recorded results were used. Although the specific refractive energy has been calculated for each sample, yet these results do not appear to be sufficiently distinctive, or by themselves of any very great value, but if the solubilities are used in conjunction with the refractive indices, very good results are obtained. The best method appears to be to multiply the refractive index by 10 times the solubility result. As the solubility, diminishes the figures increase considerably. Those Eucalyptus oils richest in eucalyptol have the greatest solubility in 70% alcohol, and have also the least refractive indices, consequently they stand at the top of the list. Only in one instance—that of a highly rectified commercial oil of *E. polybractea*—was a less figure than 15 obtained. This method seems to be a good one by which to determine the quality of a Eucalyptus oil of the eucalyptol class, and would be fatal to sophistication. It might, perhaps, be thought preferable to dispense with the factor, and to use the solubility test simply as an independent check on the refractive index. A standard partly based on these determinations, together with a qualitative test for eucalyptol, might be arranged, and if desired an ester determination might also be made. That the ester content has some influence may be assumed, because in the first 30 of the list of eucalyptol oils, no less than 11 contained esters giving a saponification number between

14 and 27. In many species the ester is most probably geranyl-acetate.

The results have been classified in groups. Those of the first, or eucalyptol oils, are arranged according to the figure obtained by multiplying the refractive index by ten times the solubility; those of the other groups are in alphabetical order. If the perfumery oils like *E. Macarthuri* and *E. citriodora* are omitted, then nearly all those oils which consist principally of eucalyptol and pinene, without phellandrene, (with the exception of *E. Risdoni* and *E. amygdalina*) have a refractive index over 1·47; those not reaching that figure are only just below. The specific gravities of the oils in this group are, in most instances, above 0·91. The solubility in 70% alcohol is a useful means of graduating the members of this group. The yields of oil are, of course, a commercial factor, and these can be obtained from the table of yields published in the work previously mentioned, page 273.

Those oils in which pinene predominates, and in which the sesquiterpene is not pronounced, have also a refractive index over 1·47, but only in one instance did the specific gravity reach 0·91. The comparative insolubility of these oils in 70% alcohol sharply separates them from those of the first group. The phellandrene oils all have a refractive index over 1·48, and in some instances over 1·49 or even higher if the sesquiterpene is in excess. Those oils in which the aldehyde aromadendral is a pronounced constituent all have a refractive index over 1·48, while some of them exceed 1·49. Aromadendral also occurs in small quantity in many oils of the eucalyptol class, but is not present in sufficient amount to exert much influence. The sesquiterpene oils have, as a rule, the highest refractive indices, exceeding 1·5 in several instances. The solubilities in alcohol of the terpene oils appear to have little distinc-

tive importance, with the exception that with those which are somewhat soluble in 80% alcohol, the presence of alcohols, esters, aldehydes, or eucalyptol is indicated.

The oil of *E. Risdoni* is rich in eucalyptol, but contains, when freshly distilled, a small amount of phellandrene. The saponification number for the esters was 27. There seems to be no just reason why the terpene phellandrene should be objected to when occurring in Eucalyptus oils, any more than the terpene pinene, providing the desired amount of eucalyptol is present also. Dr. Hall of Parramatta has shown that the objection to phellandrene as such is not warranted by results. It is, however, unusual to find phellandrene present in oils rich in eucalyptol, as the terpene is usually pinene. The other exception to the general rule is the oil of *E. amygdalina*, (not the oils from its associated species *E. radiata* and *E. dives*). The oil of this species has always appeared to be an abnormal one, and is worthy of special study; it has, however, many distinctive features by wh ch it may easily be determined.

It will be noticed by referring to the original figures that most of the oils have increased a little in specific gravity since they were first distilled, those richest in eucalyptol have, as a rule, increased the most, and the formation of an insoluble deposit in those eucalyptol oils like *E. globulus*, *E. pendula*, *E. oleosa*, etc., seems to be associated somewhat with this slight increase in specific gravity.

The refractive indices were taken with a Fuess refractometer, true for water, and using a sodium light; the results were read to minutes of arc only. The crude oils were used in all instances excèpt where otherwise stated.

The refractive indices of the following constituents occurring in the ordinary types of Eucalyptus oils are:—

Eucalyptol (Schimmel)	1·45961
Pinene (Wallach)...	1·46553

Phellandrene (Wallach) ... ... 1·488
Cymene (Brühl) ... ... 1·48465
Aromadendral ... ... 1·5141 at 16° C.
Piperitone ... ... 1·4893 at 16° C.
Sesquiterpene (prepared by distillation) 1·5116 at 16° C.

These constituents vary much in amount in the oils of the several species, but it is possible to form groups such as the eucalyptol group, the phellandrene group, etc. The refractive index of the predominant constituent will, of course, influence the result, but there is a marked uniformity between the members of the several groups, agreeing strongly with the indications suggested by the study of the leaf venations.

Eucalyptol-pinene oils; phellandrene usually absent. Refractive index mostly above 1·47 and below 1·48.

No.	Species.	Refractive index n_D 16° C.	Specific gravity $\frac{16}{15}$° C.	Specific refractive energy $\frac{n_D - 1}{d}$	Solubility in alcohol (·8722 at 15·5° C.) 1 volume requires	10 times solubility × refractive index.
1	*E. Smithii*	1·4706	·9238	·5094	1·05	15·44
	Ditto, oil of 'suckers'	1·4707	·9151	·5144	1·15	16·91
	Ditto, com. crude 5·03	1·4689	·9172	·5112	1·05	15·42
2	*E. Bridgesiana* ...	1·4723	·9327	·5064	1·05	15·46
3	„ *Risdoni*	1·4738	·9373	·5049	1·05	15·47
4	„ *pulverulenta* ...	1·4686	·9280	·5040	1·1	16·15
5	„ *dealbata*	1·4705	·9268	·5077	1·1	16·17
6	„ *stricta*	1·4711	·9254	·5090	1·1	16·18
7	„ *polyanthema* ...	1·4736	·9346	·5047	1·1	16·21
8	„ *oleosa**	1·4746	·9319	·5093	1·1	16·22
9	„ *cordata*	1·4695	·9265	·5067	1·15	16·89
10	„ *cinerea*	1·4706	9198	·5116	1·15	16·91
11	„ *populifolia*	1·4709	·9246	·5093	1·15	16·91
12	„ *Cambagei**	1·4720	·9243	·5106	1·15	16·92
13	„ *sideroxylon*... ..	1·4725	·9219	·5125	1·15	16·93
14	„ *pendula*	1·4732	·9337	·5068	1·15	16·94
15	„ *bicolor*	1·4734	·9266	·5109	1·15	16·94
16	„ *Maideni*	1·4736	·9253	·5117	1·15	16·94
17	„ *cneorifolia** ...	1·4747	·9194	·5163	1·15	16·96
	Ditto, F. & Co., crude	1·4774	·9375	·5092	1·1	16·25
18	*E. maculosa*	1·4741	·9278	·5109	1·17	17·24
19	„ *Morrisi*	1·4693	·9191	·5106	1·2	17·63
20	„ *squamosa**	1·4692	·9202	·5099	1·2	17·63
21	„ *globulus*	1·4720	·9243	·5106	1·2	17·66
	Do. Platypus bd 4 yrs	1·4697	·9153	·5131	1·15	16·90
	Do. do. 8 years old	1·4738	·9392	·5044	1·15	16·95

Eucalyptol-pinene oils—*continued.*

No.	Species.	Refractive index n_D 16° C.	Specific gravity $\frac{15^\circ}{15}$ C.	Specific refractive energy $\frac{n_D - 1}{d}$	Solubility in alcohol (·8722 at 15·5° C.) 1 volume requires	10 times solubility × refractive index.
22	*E. polybractea** ...	1·4736	·9197	·5149	1·2	17·68
	Do. commer. dist. 6·04	1·4686	·9286	·5046	1·0	14·68
	Do, do. crude dist. 7·05	1·4692	·9282	·5055	1·05	15·42
	Do, same oil rectified	1·4676	·9254	·5053	1·05	15·41
23	*E. hemilampra* ..	1·4735	·9310	·5086	1·2	17·68
24	„ *longifolia*	1·4738	·9249	·5122	1·2	17·68
25	„ *intertexta*	1·4748	·9323	·5092	1·2	17·69
26	„ *Behriana*	1·4765	·9272	·5139	1·2	17·72
27	„ *Stuartiana*... ...	1·4709	·9194	·5122	1·25	18·38
28	„ *eugenioides*... ...	1·4747	·9220	·5148	1·25	18·43
29	„ *amygdalina* ...	1·4760	·9104	·5228	1·25	18·45
30	„ *punctata**	1·4774	·9297	·5135	1·25	18·46
31	„ *Rossii*	1·4741	·9202	·5152	1·35	19·90
32	„ *resinifera*	1·4755	·9194	·5172	1·35	19·91
33	„ *Seeana*	1·4706	·9146	·5145	1·37	20·14
34	„ *camphora*	1·4733	·9072	·5217	1·4	20·62
35	„ *rostrata* var. *borealis*	1·4747	·9251	·5131	1·4	20·64
36	„ *viminalis* var. (*a*) ...	1·4711	·9169	·5138	1·45	21·33
37	„ *goniocalyx*	1·4746	·9097	·5218	1·8	26·54
38	„ *ovalifolia* v. *lanceolata*	1·4711	·9119	·5166	2·0	29·42
39	„ *salmonophloia** ...	1·4738	·9069	·5225	3·5	51·58
40	„ *quadrangulata* ...	1·4692	·9075	·5170	4·0	58·76
41	„ *Bosistoana*	1·4732	·9175	·5158	5·0	73·66
42	„ *melliodora*	1·4706	·9041	·5205	6·0	88·23
43	„ *redunca*	1·4720	·9092	·5191	6·0	88·32
44	„ *conica*	1·4733	·9259	·5112	6·0	88·39
45	„ *propinqua**... ...	1·4788	·9035	·5299	8·0	118·30
46	„ *odorata** (Faulding)	1·4775	·9150	·5218	insoluble 10 volumes 70% alcohol	soluble 1 volume 80% alcohol
47	„ *occidentalis** ...	1·4774	·9128	·5230		
48	„ *dumosa**	1·4760	·9130	·5213		
49	„ *microcorys*	1·4747	·9059	·5240		
50	„ *gracilis**	1·4771	·9107	·5239		
51	„ *paludosa*	1·4773	·9095	·5248		

Pinene oils; phellandrene absent. Refractive index above 1·47 and below 1·48.

No.	Species.	Refractive index n_D 16° C.	Specific gravity $\frac{15^\circ}{15}$ C.	Specific refractive energy $\frac{n_D - 1}{d}$	
52	*E. botryoides*	1·4787	·8802	·5439	None soluble in less than 7 volumes of 80 per cent. alcohol
53	„ *calophylla*	1·4788	·8751	·5471	
54	„ *dextropinea* ...	1·4741	·8806	·5383	
55	„ *diversicolor* ...	1·4747	·9134	·5197	
56	„ *lævopinea*	1·4769	·8964	·5320	
57	„ *saligna*	1·4760	·8940	·5324	
58	„ *Wilkinsoniana* ...	1·4774	·9016	·5295	

Pinene-sesquiterpene oils; phellandrene absent. Refractive index above 1·48.

No.	Species.	Refractive index n_D 16° C.	Specific gravity $\frac{15}{15}$° C.	Specific refractive energy $\frac{n_D - 1}{d}$	
59	*E. affinis**	1·4921	·9270	·5301	None soluble in less than one volume 80 per cent. alcohol, the majority insoluble in 10 volumes 80 per cent. alcohol.
60	„ *apiculata*	1·4934	·9128	·5408	
61	„ *Baeuerleni*	1·4841	·8890	·5445	
62	„ *corymbosa**	1·4895	·8867	·5520	
63	„ *eximia*	1·4889	·8999	·5433	
64	„ *intermedia** ...	1·4878	·8838	·5519	
65	„ *lactea*	1·4898	·8794	·5570	
66	„ *maculata*	1·4861	·9035	·5380	
67	„ *nova-anglica* ...	1·4900	·9062	·5407	
68	„ *paniculata*	1·4801	·9096	·5278	
69	„ *patentinervis* ...	1·4948	·8784	·5633	
70	„ *rubida*	1·5011	·9089	·5513	
71	„ *tesselaris*	1·4881	·8962	·5446	
72	„ *trachyphloia** ...	1·4901	·8915	·5497	

Oils in which aromadendral is a pronounced constituent; phellandrene is absent. Refractive index above 1·48.

73	*E. albens*	1·4836	·9188	·5263	With the exception of No. 74, all are soluble in either one or two volumes of 80 per cent. alcohol.
74	„ *hemiphloia*	1·4910	·9084	·5405	
75	„ *marginata*	1·4946	·9112	·5428	
76	„ *punctata* var *didyma*	1·4868	·9068	·5368	
77	„ *rostrata*	1·4896	·9018	·5429	
78	„ *salubris*	1·4841	·9018	·5358	
79	„ *tereticornis*	1·4934	·9308	·5301	
80	„ *viridis*	1·4828	·9027	·5348	
81	„ *Woollsiana*	1·4895	·8998	·5440	

Phellandrene oils containing piperitone. Refractive index above 1·48, several above 1·49.

82	*E. coriacea*	1·4902	·9120	·5375	Mostly insoluble in 10 volumes 80 per cent. alcohol; none more soluble than with one volume 80 per cent. alcohol.
83	„ *delegatensis* ...	1·4881	·8645	·5646	
84	„ *dives*	1·4894	·8883	·5509	
85	„ *fraxinoides*	1·4908	·8762	·5601	
86	„ *Luehmanniana* ...	1·4937	·8846	·5581	
87	„ *obliqua**	1·4934	·8944	·5528	
88	„ *oreades*	1·4945	·8935	·5534	
89	„ *piperita*	1·4838	·9221	·5247	
90	„ *radiata*	1·4863	·8814	·5517	
91	„ *Sieberiana*	1·4886	·8947	·5461	
92	„ *vitrea*	1·4828	·8967	·5384	

Phellandrene oils in which the sesquiterpene is a pronounced constituent. Refractive index is above 1·48 and in some instances above 1·5.

No.	Species.	Refractive index n_D 16° C.	Specific gravity $\frac{16°}{16}$ C.	Specific refractive energy $\frac{n_D-1}{d}$	
93	*E. acmenoides* ..	1·5065	·9266	·5466	No. 102 is the only oil less soluble than with one volume 80 per cent. alcohol; a large number were insoluble in ten volumes 80 per cent. alcohol.
94	„ *angophoroides* ...	1·4881	·9207	·5301	
95	„ *capitellata*	1·4828	·9176	·5261	
96	„ *crebra*	1·4844	·8989	·5388	
97	„ *Dawsoni*	1·5144	·9528	·5399	
98	„ *fastigata*	1·4873	·8948	·5446	
99	„ *Fletcheri**	1·4881	·8882	·5495	
100	„ *gomphocephala* ...	1·4815	·8752	·5501	
101	„ *hæmastoma* ...	1·5013	·9196	·5451	
102	„ *macrorrhyncha* ...	1·4802	·9166	·5239	
103	„ *melanophloia* ...	1·4950	·8959	·5526	
104	„ *microtheca*	1·4895	·8866	·5521	
105	„ *nigra*	1·4871	·8838	·5511	
106	„ *ovalifolia*	1·4921	·8911	·5522	
107	„ *Planchoniana* ...	1·4878	·9166	·5322	
108	„ *pilularis*	1·4961	·8924	·5559	
109	„ *robusta*	1·4801	·8899	·5395	
110	„ *siderophloia* ..	1·5000	·9081	·5506	
111	„ *sideroxylon* v. *pallens*	1·4884	·9167	·5328	
112	„ *stellulata*	1·4902	·8766	·5589	
113	„ *viminalis*	1·4855	·9088	·5342	
114	„ *virgata*	1·5015	·9352	·5363	

Oils not classified; containing geraniol and its acetic acid ester, citral, citronellal, etc.

115	*E. citriodora*	1·4651	·8837	·5233	Soluble in 1·5 vols.
	Do. Mr. Ingham, Qld.	1·4678	·8829	·5298	70% alco. at 16° C.
116	*E. Macarthuri* ...	1·4793	·9271	·5172	Soluble in 1·3 vol-
	Do. cont. 64·73% ester	1·4763	·9252	·5148	umes 70% alcohol
	Do. cont. 68·8% ester	1·4768	·9287	·5134	
117	*E. Staigeriana* ...	1·4871	·8708	·5594	Insoluble in 6 volumes 80% alcohol
118	„ *aggregata*	1·5062	·9701	·5218	Insoluble in 10 vols. 80% alcohol

* Denotes the presence of a small amount of aromadendral in the oil.

NOTE ON THE DRIFT OF S.S. "PILBARRA."

By H. A. LENEHAN, F.R.A.S.

[With Diagram.]

[*Read before the Royal Society of N. S. Wales September 6, 1905.*]

ON March 3rd, 1905, the engineer reported to the captain that the ship had cast one of the propeller blades. On the 4th, in Lat. 20° 10′ S., Long. 171° 38′ E., the remaining blades were lost. The boat then began to drift in a N.N.W. direction for a couple of days, but on the 7th began to take a course almost due W. Late at night on the 7th as the "Pilbarra" was making direct for the S.E. point of Erromanga, and there seemed every probability of going ashore at any moment, all boats were launched, and the ship deserted to her fate. Next day the captain, when trying to find a landing place, saw his ship some miles to the westward of the island, and again set out to take charge. The drift thereafter was principally to N.W., and the "Pilbarra" was picked up by s.s. "Induna" at 6·25 a.m. on March 17th, and towed to port. I wish to record my thanks to Captain W. R. Fleetwood for the loan of his log, and also to Captain Lindeman, R.N., for placing the same at my disposal.

Date	Position at Noon. Lat. S.		Long. E.		Course.	No. of Miles Drifted.	Condition of Weather.	State of Sea.	Wind.
1905	°	′	°	′					
March 5	19	37	171	18	...	37†	moderating very thick	...	...
„ 6	19	2	171	9	...	36†	ditto	...	...
„ 7	18	42	169	58	...	68†	...	high	S.E. str.
„ 8	19	6	168	43		75†	mod., fine	...	...
„ 9	18	54	168	0	N. 73 W.	41*	...	...	...
„ 10	18	51	167	16	N. 86 W.	44*	...	moderate	...
„ 11	18	36	166	44	N. 63 W.	34*	...	...	...
„ 12	18	14	166	26	N. 38 W.	28*	...	...	...
„ 13	17	56	166	0	N. 54 W.	31*	fine	...	S.E. mod
„ 14	17	40	165	31	N. 60 W.	32*	fine	...	„ light
„ 15	17	24	165	31	...	17†	cloudy	mod. swell	„ mod.
„ 16	17	22	164	37	W	47†	fine		„ mod.

* From Ship's Log. † No. of miles computed.

REINFORCED CONCRETE, PAPER III.

The Adhesion of Concrete to the Steel Reinforcement. The Experimental Determination of the Strain Curves and the position of the Neutral Axis in a Reinforced Concrete Beam subjected to Flexure. The form of the Stress Curves derived from the actual Strain Curves. The Design of Reinforced Concrete Structures.

By W. H. WARREN, Wh. Sc., M. Inst. C.E., M. Am. Soc. C.E.,
Challis Professor of Engineering, Sydney University.

[*Read before the Royal Society of N. S. Wales, September 6, 1905.*]

THE following matters will be dealt with:—

a. The adhesion of cement mortar and concrete to steel.

b. The experimental determination of the neutral axis in a plain concrete and also in a reinforced concrete beam, and the curves of strain for loads increasing from zero to the load producing fracture, also the determination of the true form of the stress curve from the actual strain curve in a plain and in a reinforced concrete beam.

c. The safe working stresses and the fundamental equations recommended for the design of reinforced concrete structures.

a. *The adhesion of cement mortar and concrete to steel.*

The adhesion of cement mortar and concrete to steel was referred to in a former paper,[1] but the results obtained are given in connection with direct tension tests in which failure occurred by the steel bars pulling out of the heads of the specimens. In the following experiments the adhesion

[1] Further Experiments on the Strength and Elasticity of Reinforced Concrete—Proc. Roy. Soc. N.S. Wales, Sept. 7, 1904.

resistance was determined by pulling out specially prepared bars of Bessemer steel ⅝ inch diameter, from prisms 12 inches long by 4 × 4 inches in cross-section, consisting of one part of cement to three of builders' sand, and also of one part of cement to two parts of sand and two of stone broken to ¾ inch gauge.

The steel bars were prepared with parallel portions 6 inches long, abutting at the centre of the prism, and were pulled out by means of a gradually applied load in the testing machine. The results obtained are recorded in Table I., A, B, and C.

Table I.—ADHESIVE STRENGTH OF CONCRETE TO STEEL.

A. Bars with natural skin on. Hardened in air.

Number	Composition— Cement	Builders' Sand	¾ Nepean Shivers	Water per cent.	Age in Days	Surface area of bars imbedded sq. in.	Total Load pounds	Adhesion Pounds per sq. in.
I.	1	3	–	12	45	11·78	2550	216·5
II.	1	3	–	12	45	11·78	2600	221·0
III.	1	2	2	10	45	11·78	2175	184·5
IV.	1	2	2	10	45	11·78	2000	170·0
B. Bars cleaned with emery paper before embedding. Hardened in air.								
I.	1	3	–	12·5	45	11·78	1400	118·0
II.	1	3	–	12·5	45	11·78	850	72·0
III.	1	2	2	10	44	11·78	1820	154·0
IV.	1	2	2	10	44	11·78	1825	155·0
C. Bars cleaned with emery paper before embedding. Hardened in water.								
I.	1	3	–	12	45	11·78	1820	154·0
II.	1	3	–	12	45	11·78	2255	191·0
III.	1	2	2	10	45	11·78	2410	204·0
IV.	1	2	2	10	45	11·78	2250	191·0

b. *The experimental determination of the neutral axis in a plain and in a reinforced concrete beam, also the curves of strain for loads increasing from zero to the load producing fracture.*

In deriving the equations for determining the position of the neutral axis and the moment of resistance of a transverse section in a reinforced concrete beam, it has been assumed by all authorities up to the present, that a trans-

verse plane section before flexure remains a plane section after flexure. On this assumption the curves of stress on each side of the neutral axis have been derived. The stress strain curve obtained from testing plain concrete prisms in compression under gradually applied loads, in which the abscissæ represent the strains and the ordinates the loads producing them are of approximate parabolic form,[1] and this form is usually assumed for the curve representing the compressive stress from the neutral axis to the extreme fibre, where the maximum ordinate represents the intensity of compressive stress at the extreme fibre.

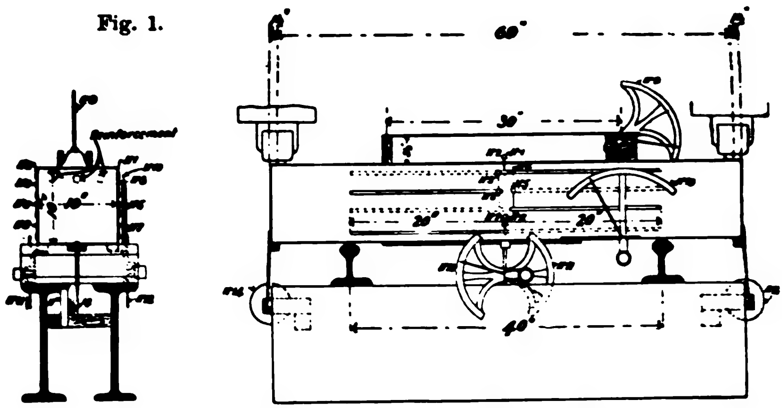
In order to test the accuracy of this assumption, ten beams were made 72 inches long, of square cross section 10 by 10 inches, one beam was of plain concrete, the others were reinforced each with three rods, varying in diameter from $\frac{5}{8}$ of an inch to 1 inch. The beams were supported at points 40 inches apart and loaded at each extremity, so that the bending moments and corresponding stresses between these points of support were nearly constant. Four sets of Martens' mirror extensometers[2] were arranged on each side of the beam to be tested, at equal distances from the centre of the beam, and Martens' sectors were arranged at the top and bottom of the beam in order to determine the strains produced by the loads applied, not only at the extreme fibres, but at four other points in the depth of the beam on each side. Martens' sectors and dials were also attached to the beam in order to determine the end and centre deflections. The loads were applied at the ends of the beam by means of two hydraulic presses, and two rolled steel beams, resting upon the table of a

[1] Further Experiments on the Strength and Elasticity of Reinforced Concrete.—Proc. Roy. Soc. N.S. Wales, Sept. 7, 1904.

[2] Apparatus for ascertaining the minute strains which occur in materials when stressed within the elastic limit, by Prof. Warren. The theory of the Reflecting Extensometer of Prof. Martens, by G. H. Knibbs—Proc. Roy. Soc. N.S. Wales, July and August 1897.

special form of vertical Buckton testing machine, carry the knife edges upon which the concrete beam rests.

Fig. 1.



Arrangement of Apparatus

Nos. 1 - 8, Martens' Mirrors. Nos. 9 - 12, Sectors. Nos. 13, 14, Dials.

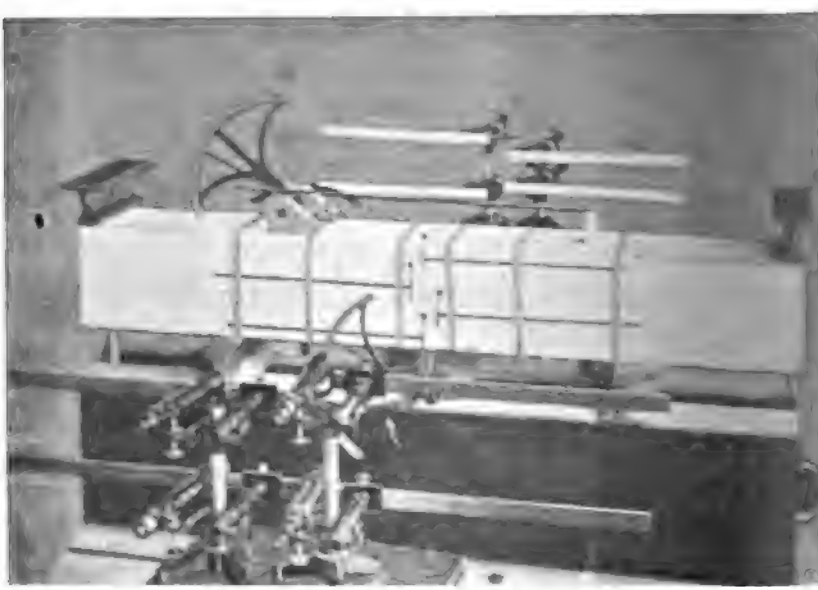
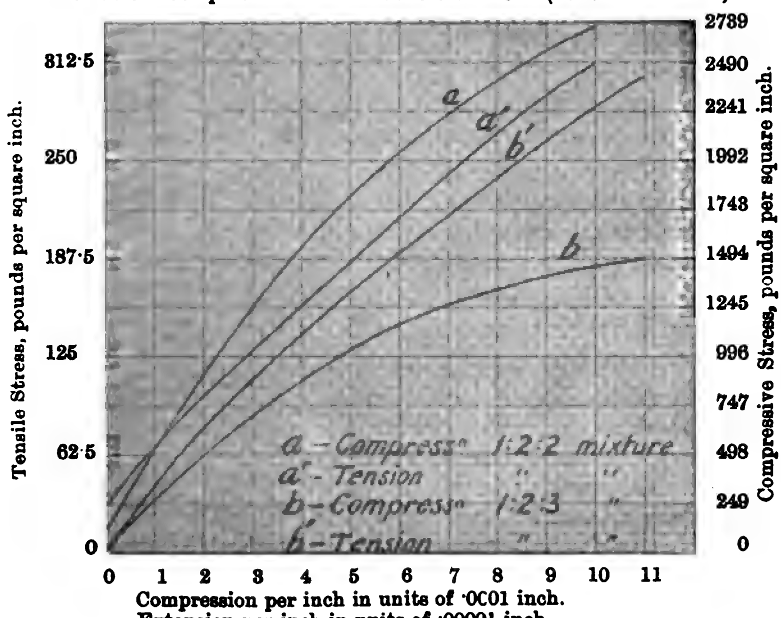


Fig. 2.

The arrangement of the fourteen instruments used in the determination of the various deformations is shown in Fig. 1, but the number denoting each instrument was used for convenience in tabulating the results from which the diagrams Figs. 3 to 6 have been plotted, and has no reference to the numbers on these diagrams. Fig. 2 is a photograph of the beam removed from the testing machine in order to show more clearly the instruments attached to it. In order to derive the stresses from the strains producing them, recorded in the manner above described, experiments were made, on plain concrete prisms, of the same age and composition as the beams under consideration, subjected to compression, and on briquettes of the same material subjected to tension; the results obtained have been plotted in Fig. 3, and from these curves the stress can be determined for each inch in the depth of the beam when the corresponding strain is known.

Fig. 3—Stress-Strain Curves from Tensile Test of Concrete Briquettes and from Compressive Stress of Concrete Prisms (no reinforcement.)



Some of the results obtained in testing the ten beams are recorded in Table II., and in the briquettes and prisms of the concrete used in the beams in Table III.

Table II.—TRANSVERSE TESTS OF REINFORCED CONCRETE BEAMS.

6 ft. by 10 in. by 10 in. Supports 40 in. centres. Loaded at ends.
Reinforced with Bessemer steel bars, Elastic Limit = ——lbs. per sq. in.

Number	Composition— Cement : Builders' Sand : ¾" Nepean Shivers	Age in Days	Maximum Deflection measured. Inches	Load at which max. deflec. was measured	Load producing fracture, tons	B. Mt. at fracture = $14{\cdot}5 \times \frac{W}{2}$ inch tons.	Reference to Curve
I.	1 : 2 : 2 No bars	342	0·01	Tons 45	45	32·6	Fig. 4
II.	1 : 2 : 2 Three ⅝ inch bars ...	357	0·076	15	16	116·0	
III.	1 : 2 : 3 Three ¾ inch bars ...	353	0·099	19	20	145·0	
IV.	1 : 2 : 3 Three ⅞ inch bars ...	353	0·081	18	19	137·75	
V.	1 : 2 : 2 Three ⅞ inch bars ...	357	0·146	21	22	159·5	
VI.	1 : 2 : 3 Three 1 inch bars ...	365	0·157	22	22	159·5	
VII.	1 : 2 : 2 Three 1 inch bars ...	369	0·109	26	28	203·0	Fig. 5
VIII.	1 : 2 : 2 Three 1 inch bars ...	314	0·074	24	26	188·5	,,
IX.	1 : 2 : 2 Three 1 inch bars ...	320	0·079	26	29	210·25	,,
X.	1 : 2 : 2 Three 1 inch bars ...	319	0·069	24	27	195·75	,,

Table III.—TENSILE TEST OF CONCRETE BRIQUETTES.

Number	Composition— Cement : Builders' Sand : ¾" Nepean Shivers	Age in Days	Cross Section inches	Total Load pounds	Load lbs. per square inch	Reference to Curve
I.	1 : 2 : 2	341	4 × 4	6700	418·7	Fig. 3a'
II.	1 : 2 : 2	339	4 × 4	6450	403·7	

Table IV.—COMPRESSION TEST OF CONCRETE PRISMS.

Length equal 12 inches.

Number	Composition— Cement : Builders' Sand : ¾" Nepean Shivers	Age in Days	Cross Section inches	Total Load pounds	Load lbs. per square inch	Reference to Curve
I.	1 : 2 : 2	340	6 × 6	104832	2912	Fig. 3a
II.	1 : 2 : 2	337	6 × 6	94080	2613	

Fig. 4—Distribution of Strain and equivalent Stress, over the Cross Section of a Plain Concrete Beam as experimentally determined.

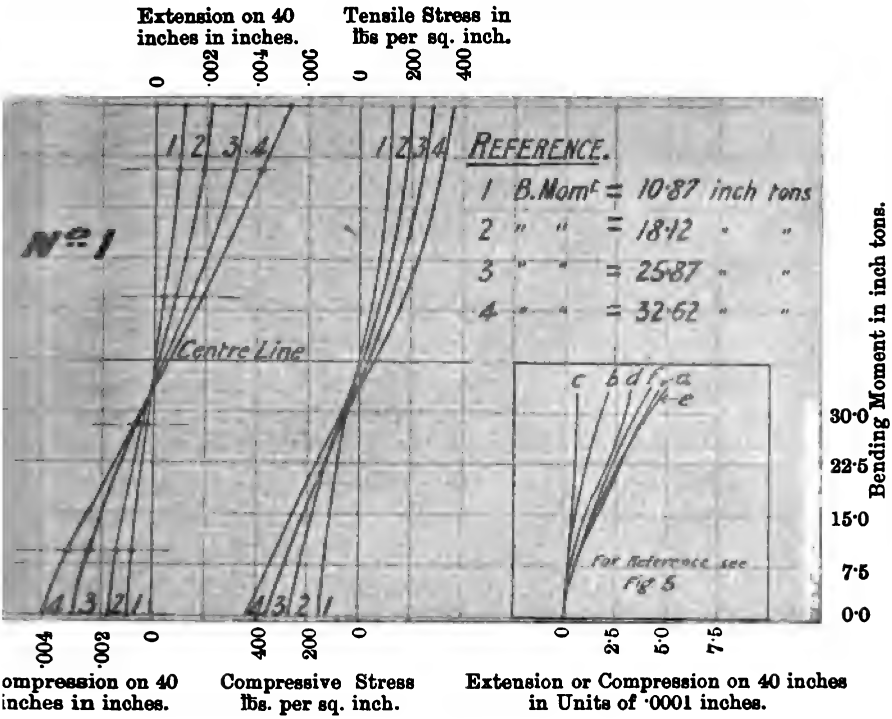
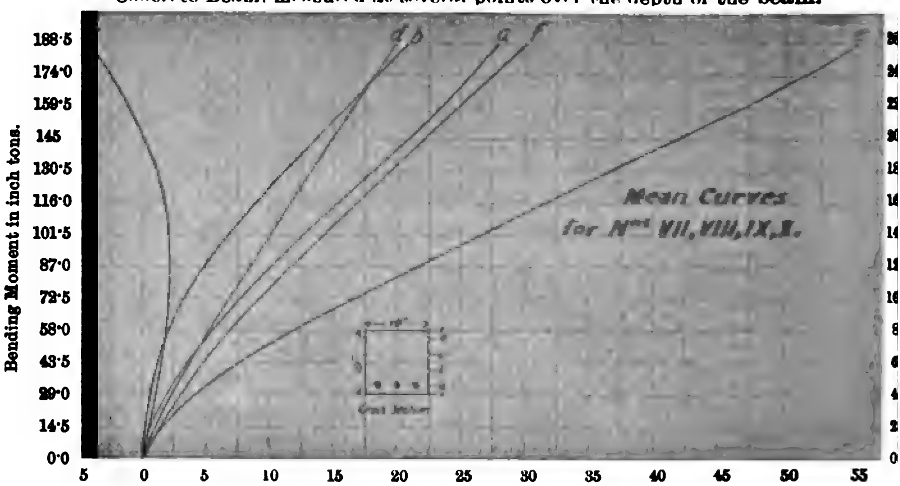


Fig. 4 shows the strain diagram and the stress diagram derived from it, by means of Fig. 3, for a plain concrete beam without reinforcement. The stress diagram showing the distribution of stress in the depth of the beam is shown on the right of the strain diagram.

The curves *c*, *b*, *d*, *f*, *a*, *e*, have been plotted from the deformations obtained by the various instruments attached to the beam at the positions shown in Figs. 1 and 2, the exact distances from the top and bottom and centre of the beam are the same as described in the reference printed under Fig. 5. The results obtained have been used in drawing the strain curves 1, 2, 3, and 4.

Fig. 5—Curves showing the Extension (or Compression) of Fibres of a Reinforced Concrete Beam, measured at several points over the depth of the beam.



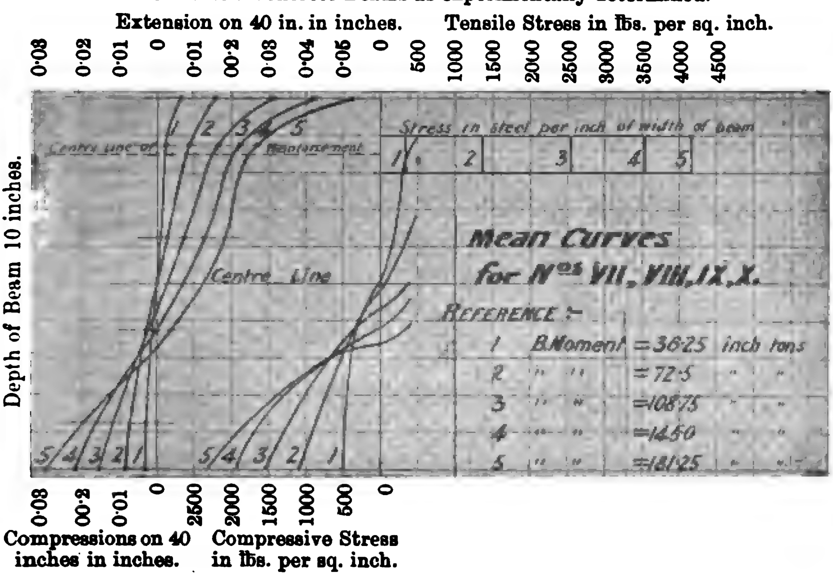
REFERENCE TO CURVES.

a—Extension measured 1¼ inch from tension face of beam
b—Extension measured 1¼ inch from centre of beam on tension side
c—Compression measured 1¼ inch from centre of beam on compression side
d—Compression measured 1¼ inch from compression face of beam
e—Extension measured on tension face of beam
f—Compression measured on compression face of beam

It will be observed that the neutral axis remains in the centre of the depth up to a bending moment of one-third that necessary to produce fracture, and that it gradually moves towards the compression face of the beam as the bending moment increases, the maximum deviation being 0·8 of an inch. The strain curves 1, 2, 3, and 4, Fig. 4, show how nearly a plane section before flexure remains a plane section after flexure. The stress curves are more curved on the tension than on the compression sides, where they approximate very closely to a straight line. The strains obtained from testing a reinforced concrete beam are recorded in Fig. 5, which gives in each case the mean of tests of four beams of the same material reinforced in a similar manner; the results obtained in the four beams were very consistent and differed very slightly from each other. Fig. 6 shows the actual lengthening or shortening plotted with reference to the depth of the beam in a similar manner to that employed in the strain curves 1, 2, 3, and

4 in the plain concrete beam Fig. 4. In Fig. 6 five strain curves are plotted for five corresponding bending moments, and the stress curves derived from the strain curves by means of Fig. 3 are complete on the compression side of the neutral axis. The curves on the tension side are necessarily incomplete as Fig. 3 does not furnish the data for continuing the curves beyond the points shown, which is the tensile strength of the plain concrete. The stress in the steel reinforcement is determined from the extensions measured, and the coefficient of elasticity of the steel.

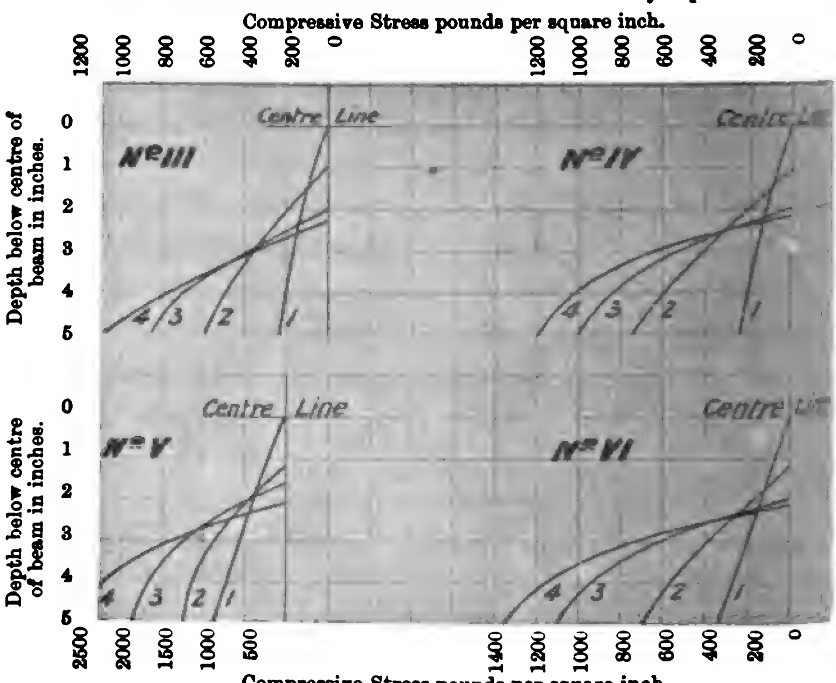
Fig. 6—Distribution of Strain, and equivalent Stress, over the Cross Section of Reinforced Concrete Beams as experimentally determined.



The curves 1, 2, 3, 4 and 5, in the strain diagram on the left of Fig. 6, show that a plane section before flexure is not a plane section after flexure, and that the deviation from the plane is greater as the bending moment increases. Again the neutral axis moves from the centre of the beam towards the compression side as the bending moment

increases. The diagram shows that the neutral axis for a bending moment of 181·25 inch tons is 1·9 inches from the centre, and for the mean bending moment obtained, in testing the four beams 199·4 inch tons, the neutral axis would be nearer to the extreme fibre in compression. The stress curves derived from the strain curves are fairly straight for a bending moment about one-third of that producing fracture, but they are curved for greater bending moments, curves 4 and 5 being approximately parabolic. Fig. 7 shows the results of testing beams III., IV., V. and

Fig. 7—Curves showing the distribution of the Compressive Stresses over the Cross Section of a Reinforced Concrete Beam as obtained by experiment.



REFERENCE.

No. III. 1 : 2 : 3	Concrete, three $\frac{3}{4}$ in. bars.	1	Bending Moment	= 32·25 in. tons.
No. IV. 1 : 2 : 3	„ „ $\frac{7}{8}$ in. bars.	2	„ „	= 72·5 „
No. V. 1 : 2 : 2	„ „ $\frac{7}{8}$ in. bars.	3	„ „	= 108·75 „
No. VI. 1 : 2 : 3	„ „ 1 in. bars.	4	„ „	= 135·0 „

Age about 360 days.

VI., but only the stress curves on the compression side of the neutral axis are shown; they are very similar to the stress curves on the compression side of Fig. 6. The neutral axis moves from the centre of the depth of the beam in all four cases, to more than 2 inches towards the extreme fibre in compression, also the curves 1 are practically straight lines, whereas 2, 3, and 4 are approximately parabolic.

The form of the curve of compressive stress in a reinforced concrete beam tested to the breaking point is therefore fairly represented by a parabolic curve, having its origin in the neutral axis, and its maximum ordinate at the extreme fibre in compression, and the equations given in a former paper,[1] express fairly well the conditions of stress in such beams. In applying the foregoing results to the practical design of reinforced concrete beams, we must remember that the curve of stress on the compression side, for working stresses, is more nearly represented by a straight line than a parabola, and that the tensile resistance of the concrete should be neglected for the sake of safety, more especially as it contributes very little to the moment of resistance of the beam.

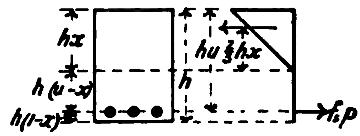
c. *The safe working stresses and the fundamental equations recommended to be used in the design of reinforced concrete.*

	Pounds per square inch
The extreme fibre stresses in concrete compression =	500
The shearing stress in concrete and the adhesion of the concrete to the steel	50
The direct compression stress	350
The tensile stress in the steel reinforcement ...	16000
The compressive stress " " ...	12000
The shearing stress " " ...	10000

[1] Further Experiments on Reinforced Concrete—Proc. Roy. Soc. N.S. Wales, Sept. 7, 1904.

No tensile resistance must be taken for the concrete.

The ratio $\frac{E_s}{E_c} = 15$



NOTE.—In the bottom line of this diagram for $h\,(1-x)$ read $h\,(1-u)$.

The fundamental equations are[*]:—

$$\frac{cx}{2} = f_s p \;...(1)$$

$$\frac{c}{f_c} = \frac{E_c}{E_s}\left(\frac{x}{u-x}\right) \;...(2)$$

$$\frac{M}{bh^2} = f_s p\left(\frac{3\,u-x}{3}\right) \;...(3)$$

$$x = \sqrt{p^2\,\frac{E_s^2}{E_c^2} + 2\,pu\,\frac{E_s}{E_c}} - p\,\frac{E_s}{E_c} \;...(4)$$

To find the area of the steel reinforcement in a beam 10 inches wide by 20 inches deep to carry 1000 pounds per foot run on a span of 24 feet.

Take $hu = 16$ in order to allow sufficient concrete below the steel bars, so that $u = 0{\cdot}8$.

The bending moment $= \frac{24000 \times 24 \times 12}{8} = 864000$ in. lbs.

$$\therefore \frac{M}{bh^2} = \frac{864000}{4000} = 216 \text{ inch lbs.}$$

$$\frac{M}{bh^2} = 16000\left(\frac{3\,u-x}{3}\right)p = 16000\left(\frac{2{\cdot}4-x}{3}\right)p = 216$$

Take $x = 0{\cdot}5$ as a first approximation,

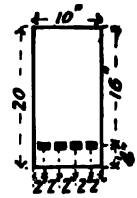
then $p\,(2{\cdot}4 - x) = 0{\cdot}0405$

$$p = \frac{{\cdot}0405}{1{\cdot}9}$$

Let a denote the area of the steel then $p = \frac{a}{bh} = \frac{a}{200} = \frac{{\cdot}0405}{1{\cdot}9}$

$\therefore a = 4{\cdot}26$ square inches.

* Further Experiments in the Strength and Elasticity of Reinforced Concrete by W. H. Warren—Proc. Roy. Soc. N. S. Wales, Sept. 7, 1904.



We may use 4 bars each $1\frac{1}{8}$ in. $\times$ $1\frac{1}{8}$ in. using this new value of p in the equation—

$$x = \sqrt{\frac{p^2 E_s^2}{E_c^2} + 2pu\frac{E_s}{E_c}} - p\frac{E_s}{E_c}$$

we find $x = 0{\cdot}486$

$$\text{Hence } \frac{M}{bh^2} = 16000\left(\frac{2{\cdot}4 - 0{\cdot}486}{3}\right)\frac{1}{40}$$
$$= 255{\cdot}2$$

and $M = 1020800$ inch pounds.

This result is nearly 20% greater than the bending moment produced by the load of 1000 pounds per foot run on a span of 24 feet. We may however, reduce the area of the steel reinforcement thus—

$$\frac{M}{bh^2} = 16000\left(\frac{2{\cdot}4 - 0{\cdot}486}{3}\right)p = 216$$

$$\therefore p = \frac{a}{200} = 0{\cdot}021$$

$$\therefore a = 4{\cdot}22 \text{ square inches.}$$

To find the safe load applied at the centre on a beam 10×10 in. when supported at points 10 feet apart: the area of the steel reinforcement is 1·8 square inches. In this case $p = 0{\cdot}018$ and $p^2 = 0{\cdot}000324$. $u = 0{\cdot}85$ $\frac{E_s}{E_c} = 15$

$$x = \sqrt{225 \times 0{\cdot}000324 + 25{\cdot}5 \times 0{\cdot}018} - 0{\cdot}27 = 0{\cdot}45$$

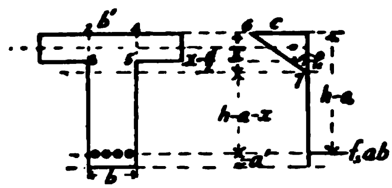
$$\therefore \frac{M}{bh^2} = 16000 \times 0{\cdot}018\left(\frac{2{\cdot}55 - 0{\cdot}46}{3}\right) = 201{\cdot}60$$

$$\therefore M = 210600 \text{ inch pounds.}$$

The actual bending moment which produced failure was 604800 inch pounds, so that the factor of safety is—

$$\frac{604800}{201600} = 3$$

Moment of Resistance of T Sections.



Let P_c = the total compressive strength in the concrete
,, P_c' = the compressive stress in the stem of the T
,, P_c'' = the compressive stress in the flange of the ,,
,, P_s = the tensile stress in the steel
,, S = the shearing stress in the concrete in pounds per square inch

a = the sectional area of the steel per inch width of the beam

then—
$$ab\, f_s = P_c = P_s$$
$$ab = \frac{P_c}{f_s} = \frac{P_s}{f_s}$$

Let S_h = the total shear between the rib and flange along their plane of union
,, S_v = the total vertical shear on the two planes 2-3 and 4-5

Assume that $S = \frac{c}{8}$ and also $P_c'' = S_h = S_v$ These assumptions are on the safe side.

It is clear that for equal strength in shear b should be equal to $2d$

If l = the span of the beam in feet

$$S_h = \frac{S}{2} \times b \times \frac{l}{2} \times 12 = 3\, b\, S\, l$$

$$S_v = \frac{S}{2} \times 2d \times \frac{l}{2} \times 12 = 6\, d\, S\, l$$

$$\frac{h - a' - x}{x} = \frac{f_s}{c}\frac{E_c}{E_s}$$

Since the stress-strain curve is a straight line in compression 6 – 7, and $\rho_c =$ the intensity of compressive stress on the plane 3 – 5 we have

$$\frac{\rho_c}{c} = \frac{x - d}{x} \quad \therefore \quad \rho_c = \frac{c(x-d)}{x}$$

$$\therefore P_c' = \frac{b}{2}(x - d)^2 \frac{c}{x}$$

$$P_c'' = \frac{b'd}{2}(\rho_c + c) = \frac{b'cd}{2x}(2x-d)$$

$$S_h = 3bsl = P_c'' = \frac{b'cd}{2x}(2x-d)$$

$$s = \frac{c}{8}$$

$$\therefore S_h = \frac{3}{8}bcl = \frac{b'cd}{2x}(2x-d)$$

$$\therefore b' = \frac{6blx}{8d(2x-d)}$$

$$\therefore P_c'' = \frac{6blx}{8d(2x-d)} \times \frac{cd(2x-d)}{2x} = \frac{3}{8}blc$$

$$P_c = P_c' + P_c'' = \frac{bc}{2x}(x-\mathrm{d})^2 + \frac{3blc}{8}$$

$$\therefore M = \frac{2P_c'}{3}(x-d) + P_c''\left(x - \frac{d}{2}\right) + P_s\,(h - a' - x)$$

$$M = \frac{bc}{3x}(x-d)^3 + \frac{b'cd}{4x}(2x-d)^2 + f_s ab\,(h-a'-x)$$

Example—Let $h = 36$ inches

$b' = 36$ inches

$b = 12$ inches

$a' = 3$ inches

$d = 6$ inches

$\frac{E_s}{E_c} = 15$

$c = 500$

$f_s = 16000$

$s = 50$

$ab = 7{\cdot}5$ square inches

$$\frac{h - a' - x}{x} = \frac{f_s}{c} \frac{E_c}{E_s}$$

$$\therefore \frac{33 - x}{x} = \frac{16000}{500 \times 15} \quad \therefore x = 10{\cdot}53$$

$$M = \frac{12 \times 500}{31{\cdot}59} (4{\cdot}53)^3 + \frac{36 \times 500 \times 6}{42{\cdot}12} (15{\cdot}06)^2$$

$$+ 16000 \times 7{\cdot}5 \, (22{\cdot}47)$$

$$= 3{,}295{,}594 \text{ inch pounds.}$$

The author wishes to thank Messrs. Gummow and Forrest Steel Concrete Engineers, for their kindness in making the concrete beams referred to in the tests given in this paper. He also wishes to acknowledge the valuable assistance rendered by Mr. A. J. Gibson, Assoc. M. Inst. C.E. and Mr. J. M. C. Corlette, B.E., in connection with the testing and recording the results obtained.

ON THE OCCURRENCE OF INCLUSIONS OF BASIC PLUTONIC ROCKS IN A DYKE NEAR KIAMA.

By C. A. SÜSSMILCH, F.G.S.

[*Read before the Royal Society of N. S. Wales, September 6, 1905.*]

THE inclusions (Xenoliths) referred to in this note were obtained by Mr. E. A. Perry and myself from the Bombo Quarries, which are situated at Bombo Point, about two miles north of Kiama. They consist of rounded fragments from 1 to 7 inches in diameter, embedded in a basic dyke rock, which microscopic examination shows to be a monchiquite. The permo-carboniferous lava flows, in which the Bombo quarries occur have recently been described by Messrs. J. B. Jaquet, G. W. Card,[1] and L. F. Harper, as an orthoclase basalt, and in the same paper they also map and describe a number of dykes of olivine basalt and monchiquite intruding these flows at Bombo Point. The specimens containing the plutonic inclusions were found near the north-east of the quarry, as loose fragments on the quarry floor. A careful search failed to obtain them *in situ*. A microscopic examination of the monchiquite shows it to be identical with that described from the dyke No. 36 on the map accompanying the above mentioned paper, and if this dyke continues in the direction indicated, it would cross the quarry just about at the place where our specimens were obtained. There is little doubt therefore that these specimens formed part of a continuation of this dyke.

[1] Geology of the Kiama-Jamberoo Districts.—Records of the Geological Survey of N.S. Wales, Vol. VIII., part i., by John B. Jaquet, A.R.S.M., F.G.S., George W. Card, A.R.S.M., F.G.S., and L. F. Harper, F.G.S.

Petrographical Description of the Inclusions.

The following plutonic rocks were found to occur (1) hypersthene gabbro, (2) augite peridotite, (3) enstatite peridotite (saxonite), (4) pyroxenite. These all occur in the form of more or less rounded fragments and boulders embedded in the monchiquite, the roundness being probably the result of corrosion by the molten dyke rock.

I. Hypersthene Gabbro.

a. *Megascopic Characters.*

Colour, black and white, mottled
Fracture, rough
Crystallinity, phanerocrystalline
Granularity, { relative, even; absolute, medium, grainsize about 2 mm.
Minerals visible, 1. plagioclase, 2. pyroxene.

b. *Microscopic Characters.*

Texture { 1. Crystallinity, holocrystalline; 2. Fabric, allotriomorphic granular; 3. Grainsize, 1·7 mm.

Minerals present (in order of decreasing abundance)

i. Pyroxene { *a.* augite; *b.* hypersthene
ii. Labradorite (medium variety)
iii. Magnetite

The combined pyroxenes predominate over the felspar. The relative proportions of the former vary, in some slides the hypersthene predominates over the augite, in others the contrary is the case. The rock is remarkably fresh.

II. Augite Peridotite.

a. *Megascopic Characters.*

Colour, brownish-black
Fracture, rough
Crystallinity, phanerocrystalline

Granularity, { relative, uneven
absolute, medium to coarse, individual crystals up to 10 mm. }

Minerals visible, i. olivine, ii. pyroxene, iii. biotite

b. *Microscopic Characters.*

Texture { Crystallinity, holocrystalline
Fabric, pœcilitic for the most part
Grainsize, very uneven, averages 2·3 mm. }

Minerals present (in order of decreasing abundance)
i. olivine, ii. augite, iii. enstatite, iv. biotite, v. magnetite.

The olivine occurs as more or less rounded grains from 1 to 2 mm. in diameter enclosed in the larger augite crystals; more rarely it shows crystal outlines. The characteristic alteration into serpentine is present, but the mineral is, on the whole, remarkably fresh. The augite occurs as large allotriomorphic crystal up to 10 mm. in diameter, enclosing the olivine crystals giving the characteristic pœcilitic structure. Enstatite is only sparingly present, as also is the biotite, although in one fragment the latter is fairly abundant. The order of crystallization was 1. magnetite, 2. biotite, 3. olivine, 4. pyroxene.

III. Enstatite Peridotite.

a. *Megascopic Characters.*

Colour, yellow to yellowish-green

Fracture, rough

Crystallinity, phanerocrystalline

Granularity, { relative, even
absolute, medium }

Minerals visible, olivine, pyroxene, picotite.

b. *Microscopic Characters.*

Texture { Crystallinity, holocrystalline
Fabric, allotriomorphic granular
Grainsize, average about 1·8 mm. }

Minerals present (in order of decreasing abundance)
1. olivine, 2. enstatite, 3, augite, 4. picotite.

The olivine preponderates and in some examples the rock consists almost entirely of this mineral. The pœcilitic structure so characteristic of the previous rock is absent. Augite is only sparingly present. The enstatite occurs in allotriomorphic crystals ranging up to nearly 4 mm. in diameter. The picotite occurs as small rounded granules enclosed in the other minerals, but is not abundant.

IV. Pyroxenite. Consists practically of augite only with an occasional small crystal of olivine; is phanerocrystalline and the fabric is allotriomorphic granular.

Besides these rocks several large isolated crystals of augite were found, all of which have been corroded by the enclosing rock. The largest example measured 3 inch by 2 inch by 1 inch.

Petrographical Description of the Monchiquite.

a. *Characters as seen in the hand specimen.*

Colour, blue-black
Fracture, even
Cystallinity, aphanitic
Granularity, relative, even, not porphyritic
Minerals visible, none recognisable.

b. *Microscopic Examination.*

Texture { Crystalline, hypocrystalline
Fabric, the olivine and augite are automorphic the latter more or less lath-shaped and together with the other mineral set in a more or less isotropic base.
Grainsize, average about 0·2 mm.

Minerals present (in order of decreasing abundance) 1. augite (titaniferous), 2. olivine, 3. magnetite, 4. felspar, 5. biotite, 6. apatite and an isotropic base.

Mr. G. W. Card gives the following description of the monchiquite from Dyke No. 36:—" Under the microscope

the typical isotropic base of the monchiquites is well shown. The olivine phenocrysts are more or less automorphic and may be partly or entirely serpentinised. The augite is automorphic and slightly pleochroic, some of the smaller phenocrystalline individuals may form glomero-porphyritic aggregates. Magnetite is abundant in small crystals. Felspar occurs in the groundmass to some extent. Altered leucite is probably present. The base is abundant." A comparison of these two descriptions will show that the two rocks are essentially the same.

Similar Occurrences.

In 1893 the presence of a "Chromite-bearing Rock in the Basalt at the Pennant Hills Quarry, near Parramatta was pointed out by Prof. T. W. E. David and Messrs. W. F. Smeath and J. A. Wall, in a paper to this Society. Since that time numerous fragments of gabbro, peridotite and allied rocks have been obtained from this locality; the basalt in which they are enclosed occurring in the form of a volcanic neck. In 1902 Mr. G. W. Card[1] in the Records of the Geological Survey of N.S.W., wrote as follows :—"It may be noted that enclosures of a basic character are by no means uncommon in the basalts traversing or overlying the Hawkesbury formation. Thus boulders of gabbro occur in this way at the Pennant Hills Quarry, Dundas, near Sydney, and gabbro also occurs in olivine basalt from Glen Alice, Capertee. Colourless pyroxene, resembling that of eclogite has been detected in basalts from Mount Wilson, Rooty Hill, Thirlmere and Long Bay near Sydney. In the nepheline basalt from Burragorang a pyroxene containing picotite has been noted. At Bulli a dyke contains large lumps of an aggregate of hornblende, olivine and picotite.

[1] An Eclogite-bearing Breccia from the Bingera Diamond Field by George W. Card, A.R.S.M., F.G.S., Records of the Geological Survey of New South Wales, Vol. VII., part ii.

It would thus appear that masses of holocrystalline basic rocks must exist at no great depth in this portion of Australia." Mr. Card informs me that in examining many of the other dyke rocks he has noticed many inclusions of foreign crystals (Xenocrysts) similar to those already quoted.

The occurrence of the fragments of gabbro and peridotite in the dyke at Kiama points to a similar conclusion to that arrived at by Mr. Card, and considerably extends the area beneath which basic and ultrabasic plutonic rocks probably exist in eastern New South Wales.

NOTE ON SOME SIMPLE MODELS FOR USE IN THE TEACHING OF ELEMENTARY CRYSTALLOGRAPHY.

By W. G. Woolnough, D.Sc., F.G.S.

(Communicated by Prof. T. W. E. David, B.A., F.R.S.)

[*Read before the Royal Society of N. S. Wales, October 4, 1905.*]

In the course of nearly ten years' experience in the teaching of elementary crystallography, I have found it very difficult to make the average student appreciate the connection between the number of faces in a crystallographic "form" and the elements of symmetry characteristic of the group to which the crystal belongs. I have, therefore, prepared several very simple models which, I find, make the understanding of this very important point perfectly easy to everyone.

A plane of symmetry divides a crystal into two portions which are to one another as an object and its reflection in

a mirror. The use of a mirror therefore explains the effect of a plane of symmetry exactly, and the combination of several mirrors reproduces the effect of the highest orders of symmetry.

I have constructed models representing the symmetry of the normal group of each of the six systems of crystals. Those for the cubic, tetragonal, hexagonal and rhombic systems consist of three mirrors each; that for the monoclinic system of a single mirror and a rotating axis; that for the triclinic system simply of a cork.

The mirrors should be of the thinnest gauge of glass obtainable, and must be cut very accurately to shape, and very carefully assembled, or else the multiple reflections give a distorted figure. I found it possible to get the glass cut much more accurately if ordered in rectangular shapes, than if triangles of given angles are specified. I made six inches my unit of length and then the following glasses were needed:—

5 squares, 6 inches × 6 inches (3 for rhombic, one each for tetragonal and hexagonal).

1 square, 6 inches × 6 inches, cut across diagonally (one part for cubic, one for tetragonal).

2 rectangles, 6 inches × 8·48 inches—$6\sqrt{2}$ inches—(one for tetragonal, one for monoclinic).

1 rectangle, 6 inches × 8·48 inches, cut across diagonally, (both parts for cubic).

1 rectangle, 6 inches × 6·93 inches—$4\sqrt{3}$—(for hexagonal).

1 rectangle, 6 inches × 3·46 inches—$2\sqrt{3}$—(one part for hexagonal, one part wasted).

The pieces are fixed together by means of strips of paper gummed across the edges of adjacent pieces at the back. The figures (fig. 1) are of the nature of "nets" to indicate the construction of the models for the first four systems.

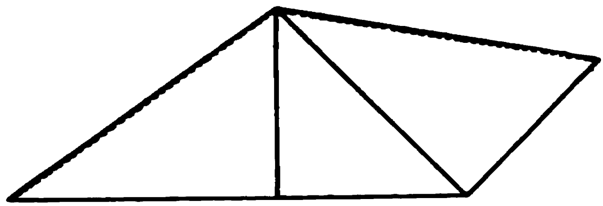


Fig 1. Cubic

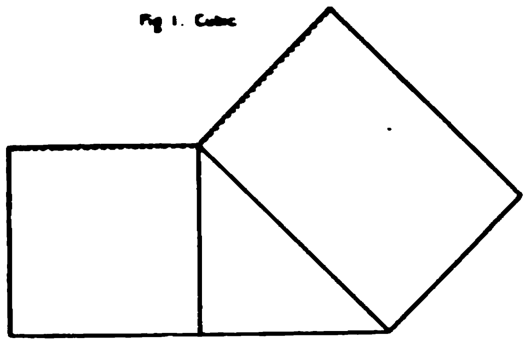


Fig 2. Tetragonal.

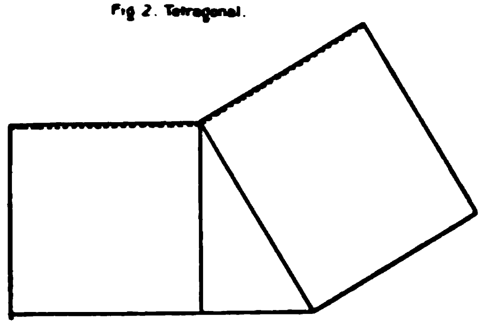


Fig. 3. Hexagonal.

Figs. 1, 2, 3, 4—Nets to show construction of the models for cubic, tetragonal, hexagonal, and rhombic systems. The edges indicated by dotted lines are to be joined.

A crystal face of the most general form is represented by a triangle of cardboard of suitable size and shape. This is placed in the solid angle between the three mirrors when the multiple reflections will reproduce all the faces of the

form, forty-eight for the cubic, twenty-four for the hexagonal, sixteen for the tetragonal, and eight for the rhombic. For the rhombic model the card may take the form of any acute angled triangle. For the tetragonal model the acute angled triangle must have one angle less than 45 degrees, for the hexagonal less than 30 degrees.

As it is rather difficult to cut a card which will fit into the cubic model, I have calculated the shapes required for some of the principal forms. It will be noticed that in figure 1 the mirrors are lettered H, V and S, respectively. The model should be placed with H horizontal and V vertical. The following are suitable triangles, the edges which are to come into contact with the mirrors being indicated by means of similar letters:

Octahedron	(111)	sides in proportion of	$H=\sqrt{3}$ $V=1$ $S=2$
Cube	(100)	,, ,,	$H=1$ $V=1$ $S=\sqrt{2}$
Dodecahedron	(110)	,, ,,	$H=\sqrt{2}$ $V=1$ $S=\sqrt{3}$
Hexoctahedron	(123)	,, ,,	$H=\cdot745$ $V=\cdot570$ $S=\cdot915$

Cards of the first three shapes show very instructively the fact that the simpler forms of the system may be regarded as limiting cases of the general form.

The models are instructive in other ways. For instance, in the case of the cubic model, if a rod be held in the position of a centronormal to any particular crystal face, the multiple reflections show the positions of all the centronormals to all the faces of the form. It will be found that there are seven distinct ways in which the rod may be held corresponding with the seven types of form possible in the group.

Thus, if the rod be laid in the dihedral angle of H and S, the positions of the six centronormals of the cube, coinciding with the three quaternary axes of symmetry, appear. If the rod is laid somewhere on the face H, the twenty-four centronormals of a tetrahexahedron appear. If the

rod is held so as not to touch any of the mirror faces, but to project between them from the trihedral angle, the forty-eight centronormals of a hexoctahedron appear, and so on. Obviously the edges H^S, S^V, V^H correspond respectively with the positions of the quaternary, ternary and binary axes of symmetry of the group.

A different procedure is adopted in the case of the monoclinic model. Here we have a plane of symmetry at right angles to it (and therefore also a centre of symmetry) with a dyad axis of symmetry. One of the large rectangles has a hole bored in its centre. Through this is passed an axis, working freely in the hole, and kept normal to the mirror by means of a cork on each side of the glass. These corks, by their friction with the glass, keep the axis in any position it may be placed. Two exactly similar pieces of card of convenient size and shape are cut to represent faces. One of these is fixed by one of its vertices to the outer end of the axis, its opposite side supported just clear of the mirror by means of two long pins fixed in the cork to the card. With this card in any convenient position the other card is fixed to the mirror by means of a paper hinge in such a way that it exactly coincides with the first one. A narrow "bridle" of paper is then fixed to the free surface of this second card and to the mirror to keep t in position when the other card is removed. With the cards in coincidence the reflection in the mirror shows how the plane of symmetry necessitates the development of another face (fig. 1). Now lift the hinged card a little, rotate the axis through 180 degrees and allow the hinged card to drop into its former position (supported by the bridle), and the four faces of the most general form of the normal group of the monoclinic system at once appears in a way which appeals very forcibly to the imagination of the pupil (fig. 6).

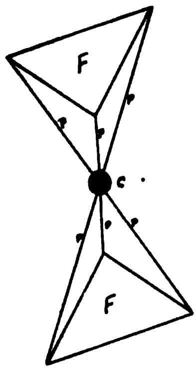


Fig. 7. Triclinic

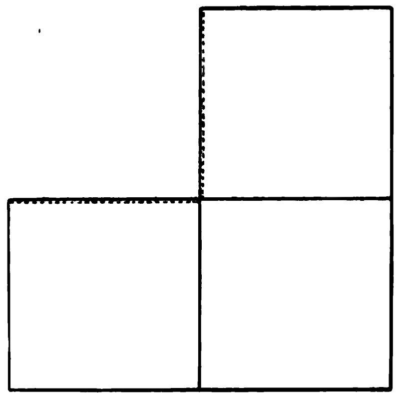


Fig. 4. Rhombic

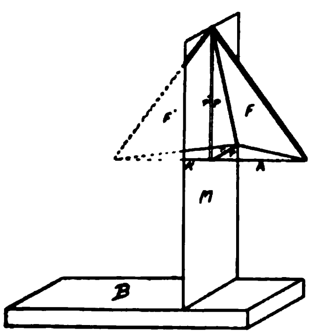


Fig. 5.

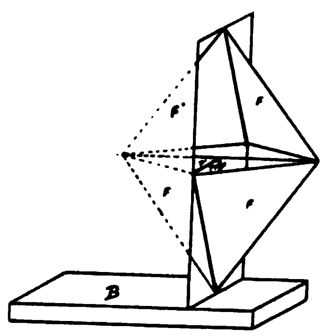


Fig 6

Fig. 5—Model for monoclinic system showing effect of a single plane of symmetry.

Fig. 6—The same with the rotating axis turned through 180°, showing the effect of a single plane of symmetry and an axis of binary symmetry at right angles to it. *M*—mirror representing plane of symmetry; *A*—rotating axis; *F*—card to represent face of a crystal; *P*—pins carrying *F*; *A'*, *F'*, *P'*—reflections of *A*, *F*, and *P* in *M*.

Fig. 7—Model for triclinic system showing effect of a centre of symmetry without any other element of symmetry. *C*—cork carrying pins and representing centre of symmetry; *F*—card to represent face of a crystal; *P*—pins carrying *F*.

The triclinic model consists simply of a spherical cork, on opposite sides of which, supported by large pins are two triangular cards in the positions necessitated by the centre of symmetry, which is the sole element of symmetry of the group.

Provisional DETERMINATION of ASTRONOMICAL REFRACTION, from Observations made with the Meridian Circle Instrument of the Sydney Observatory.

By C. J. Merfield, F.R.A.S.,

Mitglieder der Astronomischen Gesellschaft.

[*Read before the Royal Society of N. S. Wales, November 1, 1905.*]

CONTENTS.

1. Introduction.

For some years past the meridian circle instrument of the Sydney Observatory has been in constant use for observing the transits and zenith distances of certain stars. The working lists have been prepared for the purpose of providing data for deducing the constants of reduction for the photographic plates, taken with the astrographic telescope. Eventually the positions of the stars, observed

with the meridian circle, will be recorded in a catalogue that may be used for other purposes. The value of such a catalogue will depend largely on the final methods adopted in discussing the data, and publishing the investigation for the benefit of future research work in other directions.

No modern star catalogue is complete without appending an investigation into the systematic corrections required to reduce the observations to some acknowledged standard or system, such as that of Newcomb, Boss, or Auwers. An investigation of this nature is essential to define the value of the whole work. In this connection Dr. Auwers has perhaps done more than any other astronomer; through his labours it is now possible to reduce the data of almost every published star catalogue to a uniform system.

The present paper, together with another on the "Latitude of the Sydney Observatory," is preliminary to the question of preparing a star catalogue to be issued from the Sydney Observatory.

My best thanks are due to Mr. Lenehan, F.R.A.S., the Acting Government Astronomer, who kindly granted permission to use the meridian circle to obtain the necessary observations. I have also to thank Mr. Raymond, F.R.A.S., together with Messrs. Olden and Cranney, officers of the Observatory staff, for assistance in the observations and reductions.

2. Instrument.

The instrument, with which the observations were taken, is the meridian circle of the Sydney Observatory. This instrument was constructed by Messrs. Troughton and Simms of London, and erected in its present position, during the year 1875, by the then Government Astronomer, Mr. H. C. Russell, C.M.G., F.R.S.[1] A description of the instru-

[1] Retired from office 1905, February 28.

ment[2] is given in "Astronomical Results, Sydney Observatory 1879-80-81.

The instrument does not conform to modern ideas of construction, nevertheless it is a remarkably good one, and built on a secure foundation, the instrumental corrections remain normal during long intervals of time, in this connection it has given no trouble.

3. The Observing Room.

The observing room for the meridian circle is situated in the central part of the main building. The observing slit measures only fifteen inches in width, and is provided with shutters on the roof of the building, a door and sliding windows are used for closing the opening in the northern and southern walls respectively. The general arrangement, originally very defective, is now much better, but the room is too small and badly situated for the fundamental instrument of the Observatory.

4. Meteorology.

The standard thermometer is exposed in a louvred shed 12 feet by 12 feet, with walls about 12 feet 6 inches high; the cover is in the form of a pyramid, the base of which rests on the four walls, the apex being 13 feet from the floor level. This shed is some 50 feet due south of the meridian circle. The barometer is in the main building, suspended on brackets attached to the southern face of the equatorial instrument pier on the ground floor. The readings of the barometer and attached thermometer were obtained from the records of the meteorological branch of the Observatory, as well as that of the standard thermometer. The variations of these were obtained from the self recording instruments. A thermometer was also read

[2] A reproduction of a photograph of this instrument is given in the volume noted, over the title "Sydney Transit Instrument and Reverser."

at stated times during the evening's work, the indications showing that the observing room was generally between three and five degrees higher in temperature than that denoted by the external thermometer.

5. Method of Determining the Refractions.

Notation.

z' = Apparent zenith distance.
δ' = Distance, in arc, from the equator, measured on a great circle at right angles thereto, positive towards the north.
ϕ = Latitude
r = Refraction observed
r' = Refraction calculated from tables.
The suffixes n and s refer to north and south.

If we put

$$\delta'_n = \phi + (z'_n + r_n) \ldots\ldots\ldots 1$$

$$\delta'_s = \phi - (z'_s + r_s) \ldots\ldots\ldots 2$$

and subtract equation (2) from (1) then

$$\delta'_n - \delta'_s = z'_n + z'_s + r_n + r_s$$

Put

$$X = \delta'_n - \delta'_s$$

$$Y = z'_n + z'_s$$

then

$$X - Y = r_n + r_s$$

$$2\,r_n - r_n + r_s = X - Y$$

or

$$r_n = \tfrac{1}{2}(X - Y) + \tfrac{1}{2}(r'_n - r'_s) \ldots\ldots\ldots 3$$

In a similar manner

$$r_n = \tfrac{1}{2}(X - Y) + \tfrac{1}{2}(r'_s - r'_n) \ldots\ldots\ldots 4$$

It will be noted from the above deductions, that if the northern and southern zenith distances were the same, and the meteorological data similar, then the refraction for each would be the same, that is, we should have

$$r_n = r_s$$

in which case

$$2\,r = X - Y$$

These ideal conditions could not be expected. In the method here adopted, it is assumed that the error of the quantity $\pm r'_n \mp r'_s$, deduced from the tables, can be neglected, this assumption is very near the truth, if the observed zenith distances of a pair of stars do not differ to any great extent. In this respect much care was taken in the selection of the stars to be observed, so that the zenith distances of a pair approached equality.

In the Talcott method for the determination of latitude the idea is to eliminate the refraction. To obtain the refractions by the method here shown, the idea is to eliminate the latitude from the equations.

To obtain values of r from equations (3) and (4) it is necessary to know the correct declinations of the observed stars, together with the sum of the zenith distances of a pair and the difference between the amount of refraction. The declinations of the stars adopted for this work are those of certain fundamental ones contained in Newcomb's catalogue. The positions of these stars are reduced to an absolute system and the values here used are considered to be definitive. The sum of the zenith distances have been obtained by observation with the meridian circle instrument, the difference of the refractions being deduced from a standard table. The tables here used are those which form an Appendix to the "Greenwich Observations" for the year 1853. These tables are constructed from Bessel's *Tabulæ Regiomontanæ;* assuming that the reading of the thermometer attached to the barometer is the same as the external one, this assumption will seldom lead to any sensible error.

The method here outlined has some advantages, firstly the complete elimination of the latitude and its variation ; secondly the elimination of the nadir observations, since

$z'_n + z'_s$ the sum of the zenith distances is simply the difference of the circle readings, and is therefore independent of the zenith point; and finally the time necessary to obtain sufficient data does not extend over a long interval; also the simplicity of the reductions has much to commend the method.

The disadvantage in this method is that the declinations of the stars must be known. Taking fundamental stars and a large number reduces this difficulty, which will be almost eliminated in the final results.

Having obtained the refractions in the manner explained in the preceding paragraphs, the correction to the constant of the table can be deduced from the following equation [1]

$$dr = A\, d\alpha + B\, d\beta \ldots\ldots\ldots 5$$

$$A = r/\alpha$$

$$B = \text{Sin}^2 z \sqrt{\frac{2}{\beta}} \left(\frac{dq}{d\beta} - \frac{q}{2\beta}\right)$$

Consulting an investigation by Professor Comstock,[2] it will be noted that the effect of the higher powers of $\Delta\beta$, for the barometric pressures here used, and involved in the factor

$$\beta = \frac{b}{B} = 1 + \frac{b - B}{B} = 1 + \frac{\Delta b}{B}$$

need not be taken into account.. The quantities neglected will not be sensible at zenith distances less than 80 degrees. In these reductions no modification of the factor of the refraction depending on the barometer need be made.

Therefore the coefficient β is asumed to be correct or that

$$d\beta = o$$

Equation (5) reduces to the expression

$$dr = A d\alpha = \frac{r}{\alpha}\, d\alpha$$

[1] Chauvenet. Vol. I., p. 672.

[2] Publications of the Lick Observatory, Vol. I.

hence we have

$$\frac{d\alpha}{\alpha} = \frac{dr}{r} \ldots\ldots\ldots \mathrm{x}$$

therefore

$$d \log \alpha = d \log r \ldots\ldots\ldots \mathrm{y}$$

In this manner we obtain $d \log r$ which equals $d \log \alpha$, hence obtaining $d\alpha$ from equation (x) or the correction to α of the tables.

6. Observations.

The following list of stars was observed between the dates 1905 July 3 and 1905 July 25 inclusive. For most pairs ten observations were obtained; in some cases, especially those at large zenith distances, as many as fourteen observations were taken. During the period of time occupied in obtaining the data for this investigation, about 512 zenith distances and 24 determinations of the nadir were taken, necessitating 2384 micrometer readings and 608 pointer indications. From this number only two observations of zenith distance had to be rejected.

Weights depending on the definition, and varying from 1 to 5, were assigned to each evening's work. These were used in the preliminary calculations and also in the discussion of the final ones obtained from the mean errors of observation.

The evening's work consisted in obtaining, as far as possible, the circle readings for each star given in the list, the nadir being taken just before and again at the conclusion of the observations. As stated previously, the nadir readings were not here necessary, but were taken for the object of deducing a value of the latitude of the meridian circle instrument; the results of this determination form the subject of a short paper to be later communicated to the Society.

No times were recorded during the transits of the stars, the whole attention being directed to bisecting the image of the object under observation, with the horizontal wire; the bisection was made at or near the intersection of the centre wire of the transit system with the horizontal thread. In a few cases this was impossible, but in no instance was it found necessary to apply a correction for curvature.

The positions of the stars given in the appended list are taken from Newcomb's "*Catalogue of Fundamental Stars for 1875 to 1900, Reduced to an Absolute System,*" the numbers in the first column referring thereto. The positions here given were reduced to the epoch 1905, adopting Professor Newcomb's precessions and proper motions. The coefficients to be combined with the data of the ephemerides to obtain the reductions to apparent places were computed with the formulæ of the Nautical Almanac. The declinations of the stars between −77 degrees and the pole were corrected for terms of the second order by the formula

$$\delta - \delta_o = \Delta\delta_o - [6{\cdot}7367 - 10] \text{ Sin } \delta_o \cos \delta \, \Delta\alpha_o^2$$

in which δ_o is the mean and δ the apparent declination, $\Delta\alpha_o$ $\Delta\delta_o$ being the star corrections exclusive of the second order terms. The number within the brackets is a logarithm.

The heavy type indicates that the star transits below the pole during the time of observation.

STAR CATALOGUE.

No.	α			δ			Proper Motion μ_δ	Log a′	Log. b′	Log. c′	Log. d
	h.	m.	s.	°	′	″	″				
892	14	11	37·48	−83	13	59·33	−0·0136	9·6887$_n$	9·9210	1·2261$_n$	9·7350
148	**2**	**20**	**3·38**	**−69**	**5**	**29·68**	+0·0195	9·8394	9·8837$_n$	1·2153	9·7587$_n$
918	14	34	49·19	−64	33	42·06	−0·2887	9·5779$_n$	9·8480	1·1943$_n$	9·7961
927	14	41	4·81	−87	45	47·47	−0·0651	9·7986$_n$	9·8822	1·1846$_n$	9·8105
939	14	48	10·87	−82	39	29·80	−0·0636	9·7845$_n$	9·8672	1·1728$_n$	9·8259
946	14	51	44·14	+14	49	47·91	−0·0109	9·7735	9·2728$_n$	1·1666$_n$	9·8332
952	14	58	22·06	+40	45	54·09	−0·0399	9·8960	9·6674$_n$	1·1546$_n$	9·8464
198	**3**	**1**	**0·34**	**−88**	**33**	**10·35**	+0·0139	9·8579	9·8474$_n$	1·1496	9·8514$_n$
197	**3**	**2**	**3·17**	**−72**	**16**	**24·41**	−0·0263	9·9094	9·8244$_n$	1·1476	9·8533$_n$
958	15	5	19·44	−48	22	36·61	−0·0619	9·4024$_n$	9·7128	1·1412$_n$	9·8593
963	15	10	1·81	−68	19	44·53	−0·0415	9·7202$_n$	9·7978	1·1317$_n$	9·8677
971	15	17	43·75	−14	47	42·94	+0·0026	9·3530	9·2203	1·1152$_n$	9·8806
975	15	20	54·10	+37	42	36·28	+0·0814	9·9103	9·5925$_n$	1·1081$_n$	9·8857
980	15	23	54·74	+29	25	58·44	+0·0783	9·8806	9·4905$_n$	1·1011$_n$	9·8904
985	15	29	5·93	+31	40	46·18	−0·0247	9·8946	9·5070$_n$	1·0887$_n$	9·8982
986	15	30	12·64	−14	28	22·35	+0·0064	9·3456	9·1817	1·0860$_n$	9·8998
991	15	34	24·93	+40	39	44·75	+0·0483	9·9312	9·5873$_n$	1·0754$_n$	9·9058
994	15	36	28·25	−19	22	15·44	−0·1061	9·1477	9·2887	1·0700$_n$	9·9086
995	15	37	18·88	+19	58	33·42	−0·0582	9·8358	9·2993$_n$	1·0678$_n$	9·9098
1000	15	44	39·67	−3	8	23·33	−0·0279	9·5885	8·4843	1·0477$_n$	9·9194
1004	15	46	45·97	−63	8	16·31	−0·4074	9·7400$_n$	9·6901	1·0417$_n$	9·9221
246	**3**	**48**	**42·16**	**−74**	**31**	**48·81**	+0·1172	9·9664	9·7181$_n$	1·0361	9·9245$_n$
1028	15	6	7·68	−78	27	25·77	−0·0555	9·8890$_n$	9·6693	0·9803$_n$	9·9440
1030	16	9	21·97	−3	27	0·06	−0·1440	9·5795	8·4461	0·9687$_n$	9·9473
1033	16	13	17·61	−4	27	40·52	+0·0369	9·5599	8·5431	0·9542$_n$	9·9511
1037	16	17	15·58	+1	15	6·93	+0·0409	9·6565	7·9763$_n$	0·9389$_n$	9·9548
1041	16	18	51·59	−78	41	4·41	−0·0820	9·9039$_n$	9·6220	0·9326$_n$	9·9563
1046	16	21	1·70	+14	15	5·96	−0·0594	9·8089	9·0130$_n$	0·9238$_n$	9·9582
284	**4**	**24**	**22·92**	**−80**	**28**	**12·47**	+0·0719	9·9884	9·6016$_n$	0·9097	9·9611$_n$
1062	16	31	2·42	+42	37	57·38	+0·0260	9·9759	9·4088$_n$	0·8801$_n$	9·9664
293	**4**	**33**	**52·53**	**−88**	**6**	**18·38**	+0·0169	9·9893	9·5615$_n$	0·8667	9·9686$_n$
1069	16	39	38·32	+39	6	9·35	−0·0930	9·9680	9·3357$_n$	0·8379$_n$	9·9727
1080	16	49	30·74	+10	19	16·97	−0·0433	9·7764	8·7343$_n$	0·7831$_n$	9·9791
1083	16	52	0·51	−53	0	53·83	−0·0166	9·7015$_n$	9·3683	0·7679$_n$	9·9806
1086	16	56	3·05	−4	4	49·67	−0·0756	9·5615	8·2922	0·7420$_n$	9·9829
317	**4**	**57**	**54·67**	**−75**	**4**	**59·40**	+0·0550	0·0182	9·4126$_n$	0·7295	9·9839$_n$
1093	17	5	20·82	−43	6	52·02	−0·3059	9·5409$_n$	9·2080	0·6753$_n$	9·9875
1098	17	11	7·74	+24	57	3·21	−0·1582	9·9061	8·9507$_n$	0·6276$_n$	9·9901
1103	17	14	23·65	+37	23	26·80	+0·0586	9·9731	9·0793$_n$	0·5980$_n$	9·9913

7. Errors of Graduation of the Circle.

The errors of graduation of the circle, used in obtaining the observations, have never been adequately determined. A cursory examination of certain records found in the Observatory books seemed to indicate that the errors were not large, and that the circle is a fairly accurate one. In this connection no corrections have been applied to the observations used in this investigation. If circumstances permit, it is intended to examine the circles of this instrument. The results may form the subject of a future communication to the Society.

8. Reduction of the Observations.

The first operation was to take the mean of the four micrometer readings and apply the result to the reading of the pointer, hence the complete circle reading denoted by C in the tabular form prepared for the computation. The errors of runs of the micrometers were taken several times during the evening's work, but these never became appreciable. From the values of C the quantity Y can now be formed. The terms δ' and X being deduced from the declinations, see equations (3) and (4). All numerical work was checked, either by duplication or by differences in some cases.

The calculated refractions were obtained by computation from the tables, adopting the height of the barometer and temperature of the air for a stated time. To correct these quantities for the state of the air at the time of observation, a table was prepared, from which the corrections could be easily interpolated.

The following examples give the reductions in the case of the two stars 975 and 317. The same form was used for all pairs without exception.

STAR CATALOGUE.

No.	α	δ	Proper Motion μ_δ	Log a′
	h. m. s.	° ′ ″	″	
892	14 11 37·48	−83 13 59·33	−0·0136	$9{\cdot}6887_n$
148	**2 20 3·38**	**−69 5 29·68**	+0·0195	9·8394
918	14 34 49·19	−64 33 42·06	−0·2387	9·577
927	14 41 4·81	−87 45 47·47	−0·0651	9·798
939	14 48 10·87	−82 39 29·80	−0·0636	9·784
946	14 51 44·14	+14 49 47·91	−0·0109	9·77
952	14 58 22·06	+40 45 54·09	−0·0399	9·8
198	**3 1 0·34**	**−88 33 10·35**	+0·0139	9·
197	**3 2 3·17**	**−72 16 24·41**	−0·0263	9·
958	15 5 19·44	−48 22 36·61	−0·0619	9
963	15 10 1·81	−68 19 44·53	−0·0415	
971	15 17 43·75	−14 47 42·94	+0·0026	
975	15 20 54·10	+37 42 36·28	+0·0814	
980	15 23 54·74	+29 25 58·44	+0·078	
985	15 29 5·93	+31 40 46·18	−0·021	
986	15 30 12·64	−14 28 22·35	+0·00	
991	15 34 24·93	+40 39 44·75	+0·0	
994	15 36 28·25	−19 22 15·44	−0·1	
995	15 37 18·88	+19 58 33·42	−0·	
1000	15 44 39·67	− 3 8 23·33	−0·	
1004	15 46 45·97	−63 8 16·31	−	
246	**3 48 42·16**	**−74 31 48·81**	+	
1023	15 6 7·68	−78 27 25·77		
1030	16 9 21·97	− 3 27 0·06		
1033	16 13 17·61	− 4 27 40·52		
1037	16 17 15·58	+ 1 15 6·93		
1041	16 18 51·59	−78 41 4·41		
1046	16 21 1·70	+14 15 5·9		
284	**4 24 22·92**	**−80 28 12·4**		
1062	16 31 2·42	+42 37 57·		
293	**4 33 52·58**	**−83 6 18·**		
1069	16 39 38·32	+39 6		
1080	16 49 30·74	+10 19 1		
1083	16 52 0·51	−53 0		
1086	16 56 3·05	− 4 4		
317	**4 57 54·67**	**−75 4**		
1093	17 5 20·82	−43 6		
1098	17 11 7·74	+24 57		
1103	17 14 23·65	+37 2		

	1
	3
	2
)	2
12	2
·24	4
.156	4
288	2
147	3

	pv^2	p
·27	0·00000162	2
·25	242	2
·054	324	1
·061	625	1
··0017	1083	3
0·0023	338	2
− 0·0075	3042	2
− 0·0076	3200	2
− 0 0045	324	4
− 0·0017	1444	4
− 0·0022	392	2
− 0·0029	147	3

− 0·0036

= 28

^{2} = 0 00000037

·INAL RESULTS.

gives the individual results for each
ıe zenith distances are also tabulated.
, the weights, given in the fifth column,
d and which are now used in all subse-
ns. The values of ϵ are in units of the
ecimals.

Stars.	*z*	*d* log *r*	ε	*p*
	°		±	
1004 – 1000	29·28	+ 0·0071	6·8	1·1
1004 – 1030	29·28	+ 0·0086	8·1	0·8
1004 – 1033	29·28	+ 0·0083	7·9	0·8
1004 – 1086	29·28	+ 0·0019	8·2	0·7
1033 – 918	29·40	+ 0·0017	7·6	0·8
1033 – 1004	29·40	+ 0·0083	7·8	0·8
1086 – 918	29·78	– 0·0025	5·4	1·7
1086 – 1004	29·78	+ 0·0019	8·1	0·8
1030 – 918	30·42	+ 0·0011	7·1	1·0
1030 – 1004	30·42	+ 0·0083	7·8	0·8
918 – 1030	30·70	+ 0·0012	7·0	1·0
918 – 1033	30·70	+ 0·0017	7·1	1·0
918 – 1086	30·70	– 0·0024	5·1	1·9
918 – 1000	30·70	+ 0·0003	7·6	0·9
1000 – 1004	30·72	+ 0·0067	6·3	1·3
1000 – 918	30·72	+ 0·0004	7·6	0·9
963 – 1037	34·47	+ 0·0017	6·6	1·1
1037 – 963	35·08	+ 0·0017	7·1	1·0
1080 – 1023	44·18	– 0·0003	3·7	3·6
1080 – 1041	44·18	– 0·0022	1·4	25·0
1023 – 1080	44·60	– 0·0003	3·7	3·6
1041 – 1080	44·82	– 0·0022	1·4	25·0
1046 – 939	48·12	+ 0·0052	1·4	25·0
1046 – 892	48·12	– 0·0018	3·7	3·6
946 – 892	48·70	– 0·0033	3·0	6·7
946 – 939	48·70	+ 0·0035	2·4	8·3
939 – 1046	48·80	+ 0·0051	1·4	25·0
939 – 946	48·80	+ 0·0035	2·2	10·0
892 – 1046	49·38	– 0·0017	3·6	3·8
892 – 946	49·38	– 0·0032	2·8	6·3

Stars.	*z*	*d* log *r*	ε	*p*
	°		±	
198 – 1098	57·58	– 0·0001	2·8	6·3
1098 – 198	58·82	0·0000	2·8	6·3
294 – 980	63·03	– 0·0015	2·0	13·0
980 – 294	63·30	– 0·0014	2·0	13·0
985 – 284	65·55	– 0·0043	2·6	7·1
284 – 985	65·70	– 0·0043	2·6	7·1
317 – 1103	71·05	– 0·0027	2·0	13·0
317 – 975	71·05	– 0·0036	2·0	13·0
1103 – 317	71·25	– 0·0027	2·0	13·0
1103 – 246	71·25	– 0·0023	1·4	25·0
975 – 317	71·58	– 0·0034	2·0	13·0
975 – 246	71·58	– 0·0031	1·7	16·7
246 – 1103	71·62	– 0·0023	1·0	50·0
246 – 975	71·62	– 0·0030	1·7	16·7
1069 – 197	72·97	– 0·0027	2·7	7·1
197 – 952	73·87	– 0·0016	3·2	5·0
197 – 991	73·87	– 0·0016	2·8	6·3
197 – 1069	73·87	– 0·0026	2·7	7·1
991 – 197	74·53	– 0·0016	2·6	7·1
952 – 197	73·63	– 0·0015	3·0	5·6
1062 – 148	76·50	– 0·0028	1·0	50·0
148 – 1062	77·05	– 0·0027	1·0	50·0

Combining the results into normals, as indicated in the arrangement of the preceding table, we have the following statement.

z	*d* log *r*	*p*
°		
29·44	+ 0·00372	7·5
30·65	+ 0·00175	8·8
34·76	+ 0·00170	2·1
44·49	– 0·00196	57·2
48·63	+ 0·00300	88·7
58·20	– 0·00005	12·6
64·04	– 0·00245	40·2
71·43	– 0·00271	160·4
73·62	– 0·00218	25·5
76·69	– 0·00261	112·7

From which we obtain

$$d \log r = -0{\cdot}00132 \pm 60$$
$$p = 515{\cdot}7$$

10. The Constant of Refraction.

The value of α, the constant of refraction used by Bessel in forming the table of refractions, *Tabulæ Regiomontanæ*, is

$$\alpha = 0{\cdot}00027895 = 57''{\cdot}538$$

This is for barometer 29·6 inches, $t = t' = 50°$ In the tables used in this investigation, no information is given with regard to any alteration of these values, so they are here adopted.

$$d \log r = dr/r = -0{\cdot}00132$$

therefore $$d\alpha = -0{\cdot}00132\alpha$$
$$= -0{\cdot}''076$$

and $$\alpha = 57{\cdot}''462$$

This reduced to the condition 760 mm. pressure at 0° and temperature 0° C. gives

$$\alpha = 60{\cdot}''283$$
$$u = 1{\cdot}0002924$$

Appended will be found a list of the most important determinations of the constant of refraction. These values are for the conditions B equals 760 mm. at 0° C., the external thermometer 0° C.

	α	u
1. Tables Pulkowa ...	60·268″	1·0002923
2. Fuess	60·122	2916
3. Greenwich 1857-65	60·120	2916
4. Pulkowa 1865 ...	60·209	2920
5. Greenwich 1877-86	60·192	2920
6. Pulkowa 1885 ...	60·058	2913
7. Munich	60·104	2915

Mean values.

$$\alpha = 60{\cdot}''153 \qquad u = 1{\cdot}0002918$$

The following is a short summary of the values of μ determined by laboratory experiments:

		μ
1.	Mascart 1877	1·0002927
2.	Lorentz 1880	2911
3.	Bénoit 1888	2923
4.	Chappuis and Rivière 1888 ...	2919
5.	Kayser and Runge 1893	2922

$$\mu = 1{\cdot}0002920$$

On examination of the normals, giving the values of $d \log r$, it is quite evident that these quantities vary with the zenith distance. This would seem to denote that the so called constant of refraction, adopted in forming the tables, not only needs correction but also a correction for every zenith distance.[1]

Now denoting by Z the zenith distance for $d \log r$ equals nought, we may form equations of condition of the following type,

$$\text{Log } \alpha_o - \log \alpha_c = d \log r = [Z - z]\, x$$

or

$$y - zx - d \log r = 0$$

in which

$$y = Zx \quad \ldots\ldots\ldots 6$$

and $\log \alpha_c$ is the value used in the tables. The suffixes denote observation and calculation respectively. In this way the following condition equations are formed after multiplying each by the square root of the weight of the absolute term.

$$\begin{array}{llll} 2{\cdot}7\ y & -\ 79{\cdot}5\ x & -\ 0{\cdot}01004 & = 0 \\ 3{\cdot}0 & -\ 92{\cdot}0 & -\ 0{\cdot}00525 & = 0 \\ 1{\cdot}5 & -\ 52{\cdot}1 & -\ 0{\cdot}00255 & = 0 \\ 7{\cdot}6 & -\ 338{\cdot}1 & +\ 0{\cdot}01490 & = 0 \end{array}$$

[1] A similar conclusion has been arrived at by Mr. R. Tracy Crawford. To his thesis on the "Determination of the Constant of Refraction" I am much indebted. See Proceedings of the California Academy of Sciences, Vol. I.

$$
\begin{array}{rrrl}
9{\cdot}4\, y - & 457{\cdot}1\, x - & 0{\cdot}02820 & = 0 \\
3{\cdot}5 & - 203{\cdot}7 & + 0{\cdot}00018 & = 0 \\
6{\cdot}3 & - 403{\cdot}5 & + 0{\cdot}01544 & = 0 \\
12{\cdot}7 & - 907{\cdot}2 & + 0{\cdot}03442 & = 0 \\
5{\cdot}0 & - 368{\cdot}1 & + 0{\cdot}01090 & = 0 \\
10{\cdot}6 & - 812{\cdot}9 & + 0{\cdot}02767 & = 0
\end{array}
$$

To make these equations more nearly homogeneous, put

$$
\left.\begin{aligned} y &= y \\ 100x &= v \end{aligned}\right\} \ldots\ldots\ldots 7
$$

and multiply the absolute term by 100.

Reducing by the method of least squares, the following system will be found, and from which the values of y and v can be determined, hence obtaining the quantities x and Z.

$$
\begin{aligned}
515{\cdot}250\, y - 326{\cdot}688\, v + 68{\cdot}4315 &= 0 \\
-326{\cdot}688\, y + 216{\cdot}437\, v - 54{\cdot}7312 &= 0
\end{aligned}
$$

Remembering that the absolute term was multiplied by 100, the following result from the solution.

$$
\begin{array}{ll}
\text{Log}\, v = 8{\cdot}0860357 & \text{Log}\, y = 7{\cdot}8062727 \\
v = 0{\cdot}0122 & y = 0{\cdot}0064
\end{array}
$$

$$[pvv] = 0{\cdot}0011673923$$

$$m - u = 8$$

$$\text{Log}\, p_y = 1{\cdot}3453805 \qquad \text{Log}\, p_v = 0{\cdot}9686940$$

$$\text{Log}\, r_{,} = 7{\cdot}9110368$$

$$r_v = \pm\, 0{\cdot}0027 \qquad r_y = \pm\, 0{\cdot}0017$$

From equations (6) and (7) we may now find Z and x.

$$Z = 52^{\circ}{\cdot}5093 = 52^{\circ}\ 30'\ 33''$$

$$x = 0{\cdot}000122$$

$$\text{Log}\, \alpha_o = \text{Log}\, \alpha_c + 0{\cdot}000122\, [52^{\circ}\ 30'\ 33'' - z]$$

11. Conclusion.

During the reductions, it was very noticeable the manner in which the observed refractions varied in accordance with the computed ones, due to the alteration in the state of the atmosphere. If observations of zenith distance of

[illegible] by some [illegible] tain the [illegible] con- [illegible] meter. [illegible] indicated [illegible] the [illegible] over [illegible] atmosphere [illegible] seem [illegible] servatory [illegible] cor- [illegible] force [illegible] by the

[illegible]

[illegible] the [illegible] would [illegible] Sydney [illegible]

[illegible] books [illegible] assuming [illegible] of [illegible]

[illegible]

[illegible] as a [illegible] we may [illegible]

[illegible] when [illegible] a value of [illegible] preceding [illegible] may be united with the [illegible]

[illegible]

* [illegible] given in the *Tabulae Regiomontanae*, are prepared with a value of α derived from Bradley's observations made at Greenwich during the years 1750 and 1762.

LATITUDE OF THE SYDNEY OBSERVATORY.

By C. J. MERFIELD, F.R.A.S.,

Mitglieder der Astronomischen Gesellschaft.

[*Read before the Royal Society of N. S. Wales, December 6, 1905.*]

1. Introduction.
2. Observation and Methods.
3. Details of Results and the final deductions.
4. Conclusion.

This forms an appendix to a paper[1] on the "Provisional Determination of Astronomical Refraction, from observations made with the Meridian Circle Instrument of the Sydney Observatory."

1. INTRODUCTION.

The adopted latitude of the Sydney "Meridian Circle Instrument" is

$$\phi_0 = -33^\circ\ 51'\ 41''\!.1$$

and this value has been used for many years—since 1860—in all reductions of observations made at the Observatory. The above value of the latitude was determined by the Rev. W. Scott, M.A.,[2] with a transit instrument, during the month of June 1859. The method used in the investigation, was to observe the zenith distance of a star, and after correcting the observation for refraction, this distance was added to or subtracted from its tabular north polar distance, according as it was north or south of the zenith; the result diminished by 90 degrees, represented the numerical value of the observed latitude.

[1] This Journal, Vol. xxxix., p. 76.

[2] The Government Astronomer for New South Wales during the years 1856-62.

During the years 1859-60-61,[1] the observed north polar distances of certain Nautical Almanac stars were compared with the tabular ones. The residuals obtained were assumed to represent corrections to the latitude adopted in the reduction of the observations.

From the several volumes mentioned in the foregoing paragraph, the following data have been deduced:

Year.	ϕ_0	No. of Observations.
(June) 1859	$-33°\ 51'\ 41''\!\cdot10$	...
1859	$-33\ \ 51\ \ 40\cdot87$	280
1860	$-33\ \ 51\ \ 41\cdot27$	316
1861	$-33\ \ 51\ \ 41\cdot61$	164

If the last three values are combined, according to the number of observations, then the result is

$$\phi = -33°\ 51'\ 41''\!\cdot21$$

The same result is obtained by a combination of the four values giving to each an equal weight.

Although the Rev. Mr. Scott, subsequent to the year 1861, adopted a value of the latitude (which is still used) he seems to have been inclined to favour a value numerically greater; his own observations confirm this view. From the date 1861 to 1904 no further investigations have been made into this question. The appended determination is to be considered a provisional one, for reasons to be noted in the paper previously cited.

2. Observations and Methods.

The observations, taken for the purpose of obtaining values of the observed refractions by the method of equal zenith distances, are available for a determination of the

[1] "Astronomical Observations made at Sydney Observatory, 1859-60-61," by W. Scott, M.A.

latitude, providing the position, on the circle, of the line passing through the zenith is known. In order that the observations, above noted, could be used for this object, the nadir was observed each evening. Two observations were taken, one before and another after the evening's work, a mean of the two was generally adopted in the reductions to find the zenith distances from the circle readings.

The fundamental equations used in these papers are

$$\delta'_n = \phi + (z'_n + r'_n)$$

$$\delta'_s = \phi - (z'_s + r'_s)$$

If we put z to denote the zenith distance corrected for refraction, then

$$\phi = \tfrac{1}{2}(\delta'_n + \delta'_s) - \tfrac{1}{2}(z_n - z_s)$$

in which δ'_n δ'_s have the same significance as previously adopted, namely the distance from the equator measured along a great circle at right angles thereto, positive towards the north.

From the foregoing equation, values of the latitude were deduced and combined in a manner to be shown. It will be noted that the latitude obtained from this equation is independent of the absolute value of the refractions. The error of the difference of the computed refractions for each zenith distance, as determined from tables, still remains, but if the difference $z'_n - z'_s$ is small, the error in this connection can be neglected. The accuracy of the latitude determined in this way depends in a large degree on the exactness of the adopted declination of the stars observed. In this investigation, the data have been taken from Newcomb's "Catalogue of Fundamental Stars for 1875 and 1900, reduced to an Absolute System" and are adopted as definitive.

3. Details of Results and the Final Deductions.

$$-\phi = 33^\circ\ 51'\ 40'' + x$$

Stars.		Number of Observations	x_0	p	px_0	$v = x_0 - x$	$p.v.^2$
971 -	1083	7	2″73	1·7	4·641	+ 1″04	1·839
986	1083	8	2·37	3·0	7·110	+ 0·68	1·387
1000	918	10	0·86	2·0	1·720	- 0·83	1·378
1030	918	9	0·63	1·4	0·882	- 1·06	1·573
1033	918	10	0·80	1·7	1·360	- 0·89	1·347
1086	918	7	0·99	2·7	2·673	- 0·70	1·323
1000	1004	10	1·46	2·7	3·942	- 0·23	0·143
1030	1004	9	1·30	2·4	3·120	- 0·39	0·365
1033	1004	10	1·40	2·9	4·060	- 0·29	0·244
1086	1004	7	1·35	6·8	9·180	- 0·34	0·786
946	892	7	1·45	3·7	5·365	- 0·24	0·213
1046	892	4	1·10	3·0	3·300	- 0·59	1·044
946	939	10	2·32	3·4	7·888	+ 0·63	1·349
1046	939	7	1·95	8·9	17·355	+ 0·26	0·602
975	246	12	2·19	3·5	7·665	+ 0·50	0·875
1103	246	12	1·52	2·4	3·648	- 0·17	0·069
975	317	12	2·11	3·5	7·385	+ 0·42	0·617
1103	317	12	1·49	4·0	5·960	- 0·20	0·160
952	197	9	2·13	1·6	3·408	+ 0·44	0·310
991	197	8	1·67	3·3	5·511	- 0·02	0·001
1069	197	12	2·10	2·2	4·620	+ 0·41	0·370
994	958	5	1·16	5·1	5·916	- 0·53	1·433
1087	963	10	1·69	5·2	8·788	0·00	0·000
1080	1023	9	2·52	1·8	4·536	+ 0·83	1·240
1080	1041	9	2·27	1·8	4·086	+ 0·58	0·606
1098	198	11	1·42	2·9	4·118	- 0·27	0·211
985	284	10	2·49	2·0	4·980	+ 0·80	1·280
980	294	10	2·33	2·4	5·592	+ 0·64	0·983
1062	148	10	1·77	1·7	3·009	+ 0·08	0·011

The weights have been computed from the mean errors of observation in the usual manner.

From the preceding table the following are obtained

$[p] = 89{\cdot}7 \qquad [px_0] = 151{\cdot}818 \qquad \text{Log: } [pv^2] = 1{\cdot}33766$

Therefore

$$x = 1{\cdot}''692 \pm 0{\cdot}''06$$

$$\phi = -\ 33^\circ\ 51'\ 41{\cdot}''69 \quad \text{Epoch 1905 July 12.}$$

To obtain the mean latitude a reduction to this quantity is necessary.

Adopting the elements given by Chandler in the *Astronomical Journal*, Vol. XVII., No. 406, the following variations

of the mean latitude at Sydney, have been calculated for the period 1905 July 1 to August 2.

Greenwich. Mean Noon.	$\phi - \phi_0$ ″
1905 July 1	— 0·134
„ 5	— 0·138
„ 9	— 0·142
„ 13	— 0·145
„ 17	— 0·147
„ 21	— 0·149
„ 25	— 0·150
„ 29	— 0·151
„ 33	— 0·151

From the above data the latitude variation, for the epoch 1905 July 12, can be found by inspection. Applying this correction, with sign changed, to the preceding value of ϕ, we obtain the mean latitude of the Sydney Meridian Instrument.

$$\phi_0 = -33^\circ\ 51'\ 41.''55 \pm 0.''06$$

4. Conclusion.

From a combination of all the available data, it must be conceded that the accepted value of the mean latitude of the Sydney Observatory is numerically too small. The probability is that the latitude now adopted is within one quarter of a second of the correct value, but, until further evidence is forthcoming, an alteration in the published value would be unjustifiable. This adopted latitude however can only be taken as provisional, and not as a definitive value of this important co-ordinate. A definitive determination of the latitude of the Sydney Observatory is worthy of due consideration. If it were ever decided to undertake such work, then the observations should be made at intervals extending over a long period of time, so that the data could be used not only for the determination of the mean latitude, but also for an investigation into the variation of this co-ordinate. For this purpose the author would advocate the construction of an instrument specially for the object in view.

A METHOD OF SEPARATING THE CLAY AND SAND IN CLAY SOILS, AND THOSE RICH IN ORGANIC MATTER.

By L. COHEN, Chemical Laboratory, Department of Agriculture.

(Communicated by F. B. GUTHRIE, F.I.C., F.C.S.)

[*Read before the Royal Society of N. S. Wales, December 6, 1905.*]

CONSIDERABLE difficulty has always been experienced in effecting the complete separation of the clay and sand fractions of those soils that contain above the average either of clay or organic matter. The chief obstacle to an exact mechanical analysis of the fine soil appears to be that the particles of clay form themselves into aggregates, very often having a minute vegetable fibre as a nucleus, and these aggregates behave in the elutriator as though they were sand grains of the same dimensions. This property possessed by organic matter or humus of cementing together the clay particles, though rendering, as a rule, the texture of the clay soils (*in situ*) more open, interferes considerably with the correct estimation of the constituent particles of the soil.

The method of preparation of a sample of soil usually employed in order to separate the clay by the action of a moving current of water is as follows:—A weighed portion is passed through a sieve which retains the stones, coarser root fibres, and gravel, and the fine soil is boiled with water until the clay particles are completely separated from the sand, and the floccules broken up. In this laboratory the sieve used allows all particles to pass through of a diameter of $\frac{1}{40}$ of an inch or less. If necessary, and this is the case

with nearly all humus soils, heavy loams, and clays, the soil is rubbed through by the fingers into a large basin with the aid of water. After allowing the fine soil to settle for half an hour, the supernatant turbid water is poured off, the residue washed into an Erlenmeyer flask and boiled for half an hour or more, according to the texture of the soil. After cooling, the contents of the flask are removed to the elutriator. A Schultze's elutriating vessel of conical shape is used, $3\frac{1}{2}$ inches in diameter at top and 6 inches deep, fitted with a brass rim, holder for funnel-tube, and overflow tube. The water is allowed to flow from a reservoir by means of a rubber tube delivering into a thistle-head tube, 15 in. long, leading down to half an inch of the bottom of the vessel, where it is drawn out into a small orifice. The rubber tube is about $\frac{1}{8}$ inch in diameter and provided with a screw-clamp to regulate the flow so as to keep the thistle tube full to the head.

When the water from the overflow tube is quite limpid, the clamp is screwed tight, the residual sand allowed to settle, the water poured off, and the sand then washed out into a basin and dried on the water-bath. This process produces good results with sandy soils and light loams containing up to about 30% of clay; where, however, this amount is exceeded, as a general rule the preliminary treatment by boiling with water alone does not yield satisfactory figures. To remedy this, several methods have been used in order to more completely break up the clay floccules into their constituent particles, of which perhaps the most efficient is that of rubbing the soil in a mortar by means of a caoutchouc pestle with a little water.

The process is very tedious and there is a decided tendency to underestimate the amount of sand present, owing to the necessity of pouring off at intervals the clay in suspension and adding fresh quantities of water. Schöne

recommends boiling the soil with a one to two per cent. solution of caustic alkali. A large quantity of clay as well as fibre is present in the residue remaining in the elutriator after the treatment of soils by the above methods, especially in the case of peaty soils or those containing from about 15% and upwards of organic matter. It seemed then that the difficulty would be overcome and the complete disintegration of the clay floccules brought about by subjecting the soil to the action of some substance before elutriation, which would dissolve the cellulose of which the fibre mainly consists.

A solution of zinc chloride in twice its weight of hydrochloric acid (40% HCl) was found to be the most convenient solvent, the ammoniacal cupric hydrate being unsuitable for the purpose. Thirty grams of a peaty soil from Bundanoon containing 22·27% of organic matter, were passed in a dry state through a wire sieve having 50 meshes to the inch. The fine soil was then boiled for half an hour in a beaker with 200 cc. of the zinc chloride reagent, and after dilution the whole was washed into the elutriating vessel. After five minutes the overflow water became perceptibly clearer, and in three quarters of an hour was perfectly clear. The weight of the residue on drying was 1·85 gram, equivalent to 6·17% of sand in the soil, the clay percentage being calculated by difference.

For purposes of comparison, 30 grams of the same soil, after being passed through the sieve, were boiled with water for 45 min. Three hours and a half elapsed before the overflow became quite free from turbidity, and the dried residue was found to weigh 17·1 gram; in other words, by this treatment the soil is estimated to contain 57% of sand. On examination of the two residues, that from the zinc chloride treatment was found to consist of nothing but clean, hard, sharp grains of sand with no perceptible

admixture of clay. On the other hand, by the water process the residual "sand" was almost entirely made up of clay floccules of the dimensions of medium sand grains, each floccule or aggregate appearing to be composed of minute particles of decayed vegetable matter to which adhered clay and particles of sand. The heavier sand grains were observed to settle down rapidly after the current of water was stopped, but the major portion of the sand was distributed throughout the clay etc. which deposited more slowly. In order to compare the disintegrating power on the clay floccules, of the zinc chloride reagent, and the 2% alkali solution recommended by Schöne[1] for soils rich in humus, 30 grams of the same soil were boiled in 250 cc. of a two per cent. solution of caustic soda for 1 hour, the gravel etc., having been previously removed as in the other cases.

Great care was necessary to keep stirring before coming to the boil, as the soil becomes very flocculent and settles rapidly. The elutriation took 8 hours, the dried residue weighing 6·4 gram equivalent to 21·3% of sand in the soil. The appearance of the "sand" presented the same defects as those observed in the water process, though in a lesser degree. Apparently the effect of the alkaline hydrate is beneficial to a certain extent, dissolving the *humus* which has a binding effect on the clay particles, but exerting no solvent action on the vegetable fibre itself (cellulose). The superiority is apparent therefore of a reagent that will eliminate both these causes of adhesion of the particles.

In order to test the value of strong nitric acid in this direction, 30 grams of the fine soil were boiled in the strong acid for one hour. The reaction in this case is very violent and there is great difficulty in preventing the whole from frothing out of the vessel, great care being required,

[1] Wiley *Agr. Analysis*, Vol. I., page 219.

especially on first warming. On dilution with water, gummy masses (cellulose nitrate) separate out, and are an obstacle to proper manipulation. The soil treated in this way required 3 hours to elutriate, the weight of residue being 5·9 grams. The latter in this case was cleaner than that produced by the alkali method, but still contained considerable quantities of clay and organic matter. Thirty grams of the same soil were also treated by heating with dilute hydrochloric acid to boiling in a beaker, powdered potassium chlorate being cautiously added, a little at a time, as the reaction is violent and attended by the escape of large quantities of chlorine. The boiling was continued for half an hour, and on elutriation 4·5 gram of residue remained, possessing the characteristics of that from the previous experiment. The overflow water became quite clear in 1 hour 45 minutes.

A stiff yellow clay soil from the Dorrigo Scrub, from which by boiling with water it was impossible to obtain reasonable figures for the sand and clay percentages, was treated by boiling 30 grams with 150 cc. of the zinc chloride reagent for half an hour. The elutriation in this case took 15 hours, but the residue after this time was a pure, clean, sharp sand, the grains varying considerably in size, entirely free from both clay and fibre, and weighing 2·8 gram, making 9·3%. The same soil by the pestling process yielded 1·6 gram sand, showing the very considerable loss of sand that occurs in this method. This soil contained a rather large amount of organic matter, viz., 15·66%, though from its appearance and physical properties, it could not be classed as a humus soil.

Most of the soils from the Myall Creek Estate, recently thrown open for settlement, presented much difficulty in the mechanical analysis, and the most unpromising of these, an exceedingly stiff black clay, was selected in order to

test the effect of the zinc chloride reagent. The soil, after pestling for some five hours, had yielded 9·2% of sand. Being too stiff to pass through the 50 mesh sieve in a dry state, 30 grams were allowed to soak in water for 15 minutes, and being by this time softened, were rubbed through the sieve into a large porcelain basin. After standing for half an hour the supernatant liquid was poured off, and the soil washed by means of 200 cc. of the zinc chloride reagent into a beaker. Forty-five minutes were allowed for boiling and the elutriation took 4 hours. The residue was of a whitish colour, and, observed under the microscope, was seen to consist of both rounded and sharp perfectly clean grains, of varying size, no fibre or clay particles being present, and weighing 8·55 grams.

The use of a solution of zinc chloride as described above will therefore be seen to be of great service in estimating the sand and clay in all soils with which other methods of treatment, preliminary to elutriation, give unsatisfactory results. Speaking generally, all heavy loams and clay soils as well as those containing more than the average quantity of organic matter, such as humus and peaty soils, may with benefit be treated by boiling with a solution of zinc chloride in twice its weight of hydrochloric acid, previous to elutriation in any of the usual apparatus.

Table showing the percentage of sand obtained on elutriation of four typical soils, after treatment with various reagents.

Soil.	Organic matter per cent.	Percentage of Sand.					
		Boiling with $ZnCl_2$ in HCl	Boiling with Water.	Boiling with 2% Soda	Boiling with strong HNO_3	Boiling with HCl and $KClO_3$	Pestling.
Peaty soil from Bundanoon	22·7	6·17	57·0	21·3	19·7	15·0	
Stiff yellow clay from Dorrigo Scrub	15·7	9·3	34·2	16·6	14·0	...	5·3
Stiff black clay from Myall Creek	8·6	28·5	...	...	...	...	9·2
Swampy soil from near Manly	35·9	·7	48 2	5·3	7·0	...	

SOCIOLOGY OF SOME AUSTRALIAN TRIBES.

By R. H. MATHEWS, L.S.,
Corres. Memb. Anthrop. Soc. Washington, etc.

[*Read before the Royal Society of N. S. Wales, December 6, 1905.*]

INTRODUCTORY.

IN 1894, when writing of the marriage systems of certain Australian tribes, I said: "Among the social institutions of a primitive people there is none of greater interest and value to the anthropologist than the study of these social systems."[1] At different times since then I have published a number of articles on the social and other customs of aboriginal tribes in all parts of Australia, but there still remains much unbroken ground in this branch of science.

Last year I reported for the first time certain subdivisions among the Ngeumba and Kamilaroi tribes,[2] which had quite escaped the observation of all previous writers. I now report for the first time the entire absence of exogamy among the Wongaibon, Kamilaroi, Ngeumba, Wirraidyuri, Barkunjee and other tribes in New South Wales and Victoria. I shall also endeavour to briefly explain the regulations regarding marriage among some tribes in Central Australia. A perusal of these pages will, it is thought, show the fallacy of the hitherto accepted belief in exogamy among Australian tribes and abrogate all the old-school notions respecting their sociology generally.

In any of my previous articles, whether published in this Journal or elsewhere, in which it may be stated that an aboriginal community comprises 'two exogamous divisions,'

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[1] *Proc. Roy. Geog. Soc.*, (Queensland) x., p. 18.

[2] This Journal, xxxviii., pp. 209 and 214.

the reader is requested to substitute 'two principal divisions.'

Sociology of the Wombaia Tribe.

In illustrating this important subject I shall begin with the sociology of the Wombaia tribe, which occupies a large area on Cresswell Creek and Burnett Downs in the Northern Territory. It will be necessary to repeat a table showing the subdivisions of these people.[1] We shall see by this table that the eight sections of women can be classified genealogically into two distinct sets, which we may distinguish as cycles, each set comprising four specific sections of women in the column headed "Wife." Each of the two cycles reproduces its own four sections in a certain rotation and has perpetual succession, as follows:

TABLE I.

Phratry.	Husband.	Wife.	Son.	Daughter.
A	Choolum	Ningulum	Palyarin	Palyareenya
	Jamerum	Palyareenya	Chooralum	Nooralum
	Cheenum	Nooralum	Bungarin	Bungareenya
	Yacomary	Bungareenya	Chingulum	Ningulum
B	Chingulum	Noolum	Yacomary	Yacomareenya
	Bungarin	Yacomareenya	Cheenum	Neenum
	Chooralum	Neenum	Jamerum	Neomarum
	Palyarin	Neomarum	Choolum	Noolum

I consider this the best form in which to prepare a table of the eight section names. The four women of a cycle are placed by themselves, and the quartette of men who are their normal husbands are set down opposite to them. This is the same arrangement which I have adopted in tables illustrating the Kamilaroi, Wongaibon, Wirraidyuri, and other tribes. I have also used similar tables in describing the Yungmunni, Chingalee, Warramonga, Jarrau and other tribes with eight divisions in their social structure in Central and Western Australia.

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[1] This Journal, XXXII., p. 75.

I provisionally call each of the cycles a phratry. Then in studying the upper half or Phratry A of the above table, we see that the women in the "wife" and "daughter" columns reproduce each other in a fixed order. The daughters belong to the same phratry or cycle as their mothers but to a different section of it. For example, Ningulum has a daughter Palyareenya; Palyareenya's daughter is Nooralum; Nooralum produces Bungareenya; Bungareenya is the mother of Ningulum, being the section name with which we started, and this series is continually repeated, no matter which name we commence with. Let us designate this series as "Cycle Z." If we take the women in the "Wife" column of Phratry B it is found that Noolum is the mother of Yacomareenya; Yacomareenya produces Neenum; Neenum's daughter is Neomarum; Neomarum has a daughter Noolum. This series also repeats itself for ever and may be distinguished as "Cycle Y."

It is evident therefore, that the women of a cycle or phratry pass successively through each of the four sections of which it is composed in as many generations, the same section name reappearing in the fifth epoch. If the totems were transmitted directly through the women, they would also remain constantly in the same cycle, and reappear in the same rotation as the women. Comprehensive investigations respecting the descent of the totems in the Wombaia tribe and its congeners, however show that the totems do not follow such a law, because the women of a cycle are not coincident with the intermarrying sections shown in Table II.

In Table I. the husbands, wives, sons and daughters are given on the same line across the page. For example, Choolum marries Ningulum, Jamerum marries Palyareenya and so on for all the others. But extended enquiries reveal the fact that a man of any stated section has potential

marital rights over three additional sections of women. Choolum's wife may be either a Ningulum as in Table I., or a Nooralum, or a Neenum, or a Noolum. That is, he can espouse a Ningulum or a Nooralum from phratry A; or a Noolum or a Neenum from phratry B. Consequently Table I. does not represent such a bisection of the community into two intermarrying moieties as would constitute exogamy. This at once raises the crucial question, Is there any real exogamy in the Wombaia or kindred tribes?

Further study of the actual intermarriages demonstrates that the four sections of women into which Choolum can marry are equally liable to be claimed as wives, though in a different order, by three other sections of men, viz.:—Cheenum, Chooralum and Chingulum. I will now submit another table, showing a category of four sections of women from among whom four specific sections of men must obtain their wives in accordance with aboriginal custom.

TABLE II.

Phratry.	Husband.	Wife.	Progeny.
A	Choolum	Ningulum	The children of each individual woman are the same as in Table I., quite irrespectively of the name of the husband.
	Cheenum	Nooralum	
	Chooralum	Neenum	
	Chingulum	Noolum	
B	Jamerum	Palyareenya	
	Yacomary	Bungareenya	
	Bungarin	Yacomareenya	
	Palyarin	Neomarum	

In consequence of any specific woman in the "Wife" column of Table II. being eligible for marriage with any one of four different sections of men in the "Husband" column, it becomes evident that such a woman's child's father might have any one of four section names, depending upon which husband she had married. Let us take Palyarin the first name in the "Son" column of Table I. as an example. If his mother, Ningulum, had married

Choolum, he will be Palyarin's direct, or "First" father. If she had mated with Cheenum, he would be the alternative, or "Second" father of Palyarin. If she had taken Chingulum as her husband, he would be the "Third" father. And if Ningulum had married Chooralum, then he would be Palyarin's "Fourth" father. That is to say, it makes no difference to Ningulum which of the four men she marries—her son will be Palyarin just the same. We observe that two of the four possible husbands of Ningulum come from phratry A and two from phratry B in Table I., which is an additional argument against exogamy.

In all cases the section name of the progeny is irrevocably determined through the mother. If Choolum marries Ningulum his children are Palyarin and Palyareenya; if he takes a Nooralum they are Bungarin and Bungareenya; if he chooses a Neenum they are Jamerum and Neomarum; and if he be allotted a Noolum they will be Yacomary and Yacomareenya. See Table I., which exhibits the children of any and every section of women.

Let us provisionally call the category or set of four women noted under the head "Wife" in the upper half of Table II. a phratry. Then it becomes manifest that the men and women of the *same* phratry intermarry among themselves, and consequently there is no exogamy of the sections.[1]

Again adopting the phratries as set down in Table II., there could not be any regular succession of the totems, either patriarchal or matriarchal. For example, if we postulate that descent is reckoned through the men, and that the eaglehawk is the totem of Choolum, who has several brothers who all inherit the same animal from their common father. By working out genealogies it can be

[1] Tables II. and III. are introduced merely for illustration. Table I., shows the correct arrangement of the sections and phratries.

demonstrated that this totem would not only be liable to be disseminated through the children of any or all the sections in phratry A, Table II., but in a few generations it could be similarly distributed to the children of some or all the sections in phratry B. Therefore there could not be any totemic partition of the tribe into two phratries or moieties; or in other words there would be no exogamy.

Furthermore, if we assume that succession of the totems is through the women and work out an example from Table II., we shall discover that half the women of each phratry would respectively confer their totems on half the women of the other. All the totems would thus be scattered through both the phratries,[1] rendering exogamy impossible. It appears then that whether we endeavour to trace the totems according to the fathers or the mothers, the result is practically the same.

The section names of the men follow a different order to those of the women—they see-saw from father to son in alternate generations. Thus Choolum has a son Palyarin, and in the next generation Palyarin has a son Choolum, and so on for all the other sections. In 1900 I published a table suggesting how descent might be counted through the men, of which the following is a copy.

TABLE III.

Phatry.	Husband.	Wife.	Son.	Daughter.
A	Choolum	Ningulum	Palyarin	Palyareenya
	Palyarin	Neomarum	Choolum	Noolum
	Cheenum	Nooralum	Bungarin	Bungareenya
	Bungarin	Yacomareenya	Chenum	Neenum
B	Jamerum	Palyareenya	Chooralum	Nooralum
	Chooralum	Neenum	Jamerum	Neomarum
	Yacomary	Bungareenya	Chingulum	Ningulum
	Chingulum	Noolum	Yacomary	Yacomareenya

[1] This statement applies only to Table II. If the totems descended through the women as arranged in Table I., they would remain constantly in the same cycle, similarly to the totems of the Wongaibon and Barkunjee, reported in later pages.

In the table I placed Choolum, Palyarin, Cheenum and Bungerin together, to constitute phratry A, and the remaining four sections formed phratry B. My reason for placing these four sections together was because they represented fathers and sons. Choolum is the "direct" father of Palyarin and the "alternative" father of Bungarin. Palyarin is the "direct" father of Choolum and the "alternative" father of Cheenum.

It seemed to me that if there was any possibility of the succession of the totems being through the men, this would be the best way of ascertaining it. But as soon as I made the discovery that Choolum, as well as all the other sections in the table, had the further right of marrying a third or a fourth section, (Table II.), it became apparent that two of the potential wives of a man of any given section would come from phratry A and the other two from phratry B. No matter in what order these four names may be arranged, it does not alter the fact that they cannot possibly form an exogamous moiety of the tribe.

The foregoing pages illustrate how all the different sections intermarry and are perpetuated. Upon this foundation the actual marriages of specific individuals are regulated by a system of betrothals, which are made after a child is born, and sometimes before that event. The selection of a wife or husband is determined through the grand-parents of the parties to the matrimonial alliance. The following short genealogical tables will elucidate the letterpress:

TABLE IV.

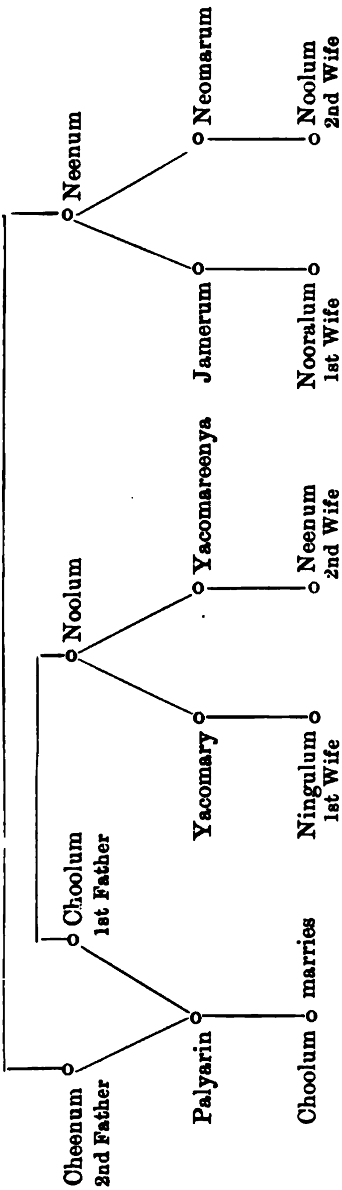
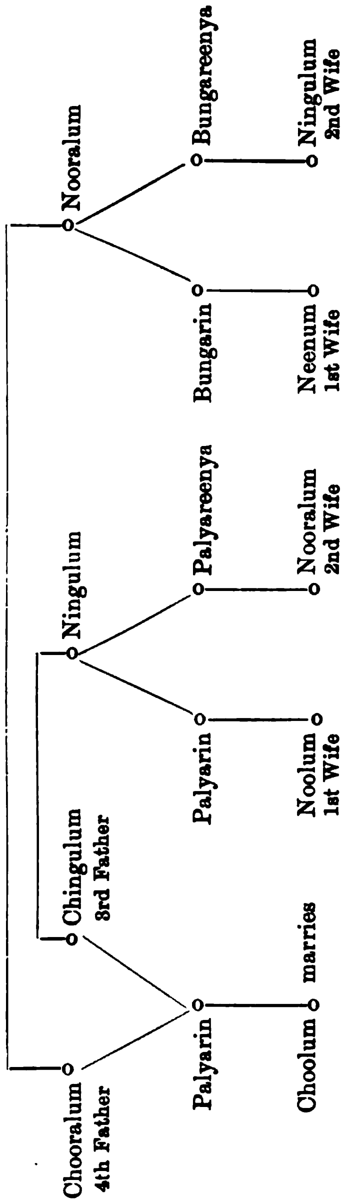


TABLE V.



It was stated in an earlier page that although a man can have but one actual father, yet this father's section name depends upon whom the man's mother had married. A man of any given section may therefore have four different nominal grandfathers. And upon tracing out the genealogies of several families by the continued assistance of trustworthy correspondents who have resided in that district for years, I find that there are, so to speak, four sorts of men in each section—for example, there are four Choolums of different lineage, whom we shall distinguish as Nos. 1, 2, 3, and 4.

Looking at Table IV., and in the left side of it, we see that the father of Choolum No. 1 is Palyarin and that Palyarin's direct or "1st Father" is Choolum. Then Choolum No. 1 marries his father's direct or "1st Father's" sister's son's daughter Ningulum as his "1st Wife" already described in Table II. Or he marries his father's "1st Father's" sister's daughter's daughter Neenum as his "2nd Wife."

If we take Choolum No. 2, with another pedigree, still looking at Table IV., then he espouses his father's alternative or "2nd Father's" sister's son's daughter Nooralum as his "1st Wife." Or he takes his father's "2nd Father's" sister's daughter's daughter Noolum as his "2nd Wife."

Perusal of Table V., introduces Choolum No. 3, whose father's "3rd Father" is Chingulum, and also Choolum No. 4, whose father's "4th Father" is Chooralum, but it is expected that the table will speak for itself. It is manifest, therefore, that whatever one of the four specific women which a man of a given section is allowed to take as a wife possesses practically the same relationship to him, although through different channels.

On account of the section name descending through the women, it would have been quite as well, or perhaps better, to have traced Choolum's pedigree back through his mother's father, instead of through his father's father. Looking at Table I., we see that Neomarum is the mother of Choolum. Examination of that table will show us that Neomarum's "1st father" is Chooralum; her "2nd father" is Chingulum; her "3rd father" is Choolum; and her "4th father" is Cheenum. Then Choolum No. 1 would marry his mother's "1st father's" sister's daughter's daughter, Ningulum, as his "1st wife." Or he marries his mother's "1st father's" sister's son's daughter, Neenum, as his "2nd wife" and so on.

According to this arrangement, the normal marriages would be those of a man's daughter's child with his sister's daughter's child. Tables IV. and V. could be easily amended, by a little transposition, for the purpose of showing all the details in full. Among the Wongaibon and Barkunjee tribes, described a few pages onward, if we follow a man's genealogy through his mother, the normal marriage would be that of a man's daughter's child with his sister's daughter's child, and so on, the same as in the Wombaia tribe.

I have placed Choolum and Cheenum together as grandfathers in Table IV. My correspondents in the Northern Territory several years ago informed me that these two sections of men are very friendly amongst themselves, and frequently marry into the same two sections of women, in inverse order.[1] Moreover, referring back to Table I., we observe that Choolum and Cheenum take their direct or tabular wives from the same cycle of women. For similar reasons I have placed Chingulum and Chooralum together as grandfathers in Table V.

[1] This Journal, xxxiv., pp. 123, 129.

According to Table IV., Choolum No. 1 marries a Ningulum or a Neenum, who is represented as his 1st or 2nd wife. Choolum No. 2 is allotted a Nooralum or a Noolum in the same way. Choolum No. 3 (Table V.) espouses a Noolum or a Nooralum. Choolum No. 4 mates with a Neenum or a Ningulum. But there are customary extensions of these rules by means of which any Choolum who is a paternal or maternal grandson of either Choolum or Cheenum (Table IV.) can marry into any one of the four sections mentioned; and any Choolum who is a paternal or maternal grandson of either Chingulum or Chooralum (Table V.) can espouse any one of the same four sections of women.

The sequence in which these marriages take place is as follows:—Choolum No. 1 marries Ningulum, Neenum, Nooralum or Noolum. Choolum No. 2 takes Nooralum, Noolum, Ningulum or Neenum. Choolum No. 3 mates with Noolum, Nooralum, Neenum or Ningulum. Choolum No. 4 espouses Neenum, Ningulum, Noolum or Nooralum.

Study of Tables IV. and V. shows that Choolum No. 1 marries as his first wife a woman belonging to "Cycle Z" mentioned in the explanation of Table I. For his second wife he takes a woman from "Cycle Y." The Choolums Nos. 2, 3 and 4 obtain a wife for each cycle in the same manner. But if Choolum No. 1, or any of the Choolums mentioned, has potential marital rights over the women of all the four sections, as stated in last paragraph, then he might be permitted to vary the order of succession of his possible wives, and select a Ningulum as his "1st" or a Nooralum as his "2nd" wife, and in that case both the women would belong to the same cycle.

When my correspondents in compliance with my request prepared lists of the section names of certain well-known men who were actually married to more than one wife among the Wombaia and other tribes, it became apparent

that the most general custom was to take a "1st" and "2nd" wife from the *same* cycle of women. Instances of polygamy were found, however, in which the wives were from both cycles in accordance with Tables IV. and V.

Although there are four sorts of men in each section—four Choolums for example in that division—they practically resolve themselves into two, namely, those who marry women of the Z Cycle and those who obtain their wives from the Y Cycle (see Table I.). This really amounts to a partition of the Choolum section into two parts instead of four. Again looking at Table I., we observe that Choolum and Cheenum take two of their possible wives, who are at the same time the two most usual, from Cycle Z and the other two from Cycle Y. The remaining two sections of men, Jamerum and Yacomary, do the same. As regards the succession of the totems, this matter has been concisely described in my paper.[1] In that article I stated that "the partition of a tribe into two exogamous portions would be impossible."

Before quitting the eight-section system, it will be well to state that everything which has been said in the preceding pages against the existence of exogamy, refers equally to the Binbingha, Chingalee, Yungmunni, Warramonga, and Arunta tribes. What I have stated is likewise applicable to all the native tribes on the Victoria river, as well as to those on Hall's Creek and surrounding country in the State of Western Australia. There is an indubitable absence of exogamy throughout them all.

SOCIOLOGY OF THE WONGAIBON TRIBES.

The territory of the Wongaibon extends approximately from about Booligal up the Lachlan river to Euabalong, thence to Nyngan, Cobar, Paddington and Ivanhoe. Their

[1] "Ethnological Notes on the Aboriginal Tribes of Queensland," *Proc. Roy. Geog. Soc.* (Queensland), xx., pp. 72 - 75.

language and initiation ceremonies have already been published by me.[1] Beyond a few fragmentary and inaccurate outlines, practically nothing has hitherto been published respecting the sociology of the Wongaibon community. Several of their subdivisions have never been even mentioned by any author until now. A table will be used to illustrate the letterpress.

TABLE VI.

Phratry.	Husband.	Wife.	Son.	Daughter.
Ngūmbūn	Murri	Ippatha	Kumbo	Butha
	Kubbi	Butha	Ippai	Ippatha
Ngurrawan	Ippai	Matha	Kubbi	Kubbitha
	Kumbo	Kubbitha	Murri	Matha

Besides the divisions shown in the table, every individual, male and female alike, claims some animal or plant or other object as his totem. Each phratry and the sections of which it is composed possesses a further distinctive division into Guaigullimba and Guaimundhan, signifying swift blood and sluggish blood respectively. These may be called "blood" divisions or castes. There is still another repartition of the community, which can be distinguished as "shade" divisions. These divisions are in reality an extension of the "blood" castes, and regulate the camping places of the people under the shades of large trees.

Intermarriages are regulated as follows:—A man of the Ngurrawan phratry and Ippai section marries a Ngūmbūn woman of the Matha section. This is the normal rule of marriage. In such a case, a man's son's child marries his sister's son's child. But it is quite lawful for Ippai to espouse an Ippatha. which represents the marriage of a man's son's child with his sister's daughter's child. These two alliances are the equivalents of Choolum marrying Ningulum and Noolum respectively in Table IV.

[1] This Journal, xxxvi., pp. 147 - 164; *Proc. Roy. Geog. Soc.* (Queensland), xi., pp. 167 - 169.

Another variation in the intermarriages of the sections allows the Ippai of our example to wed a Kubbitha or a Butha, corresponding to the marriage of Choolum with Nooralum and Neenum in the Wombaia tribe (Table IV.). In other words, a man of any given section can marry into one or other of the three remaining divisions or else into his own. It is needless to add that these facts altogether disprove the existence of exogamy in the Wongaibon tribe.

Reference to Table VI. shows us that the children follow the phratry or cycle of their mother, but they do not bear the name of her section, but that of the supplementary one, because the women of a cycle reproduce each other in continuous alternation. That is, the section name is invariably determined through the women. The totems remain constantly in the same cycle as the women and are accordingly transmitted from the mother to her progeny. Although the totems, as well as the sections and phratries, are perpetuated through the women, this does not constitute exogamy. We have already shown that an Ippai, for example, can marry into either cycle of women, and consequently a totem of either cycle.

Again, a Guaigullimba mother produces Guaigullimba children, who also take their mother's "shade." The castes of "blood" and "shade" are not necessarily coincident with the other divisions, but apply to any section according to pedigree. In short, they divide the people of every section into two sorts, and are used in tracing out the betrothals and who shall marry whom. There are for example, two sorts of Ippais. If the one who married Matha as already stated, was a Guaigullimba the Ippai who espoused Ippatha would be a Guaimundhun, analogously to the subdivisions of the Choolum section in the Wombaia tribe. An Ippai who could take a Kubbitha for a wife would be a different "blood" from the one who could marry a Butha.

Sociology of the Barkunjee Tribes.

In 1898 I wrote a paper[1] describing the initiation ceremonies of the Barkunjee and their congeners, accompanied by a map exhibiting the boundaries of the extensive region which they occupied in the western portion of New South Wales. I now desire to very briefly refer to their sociology.

The people of these tribes are segregated into two primary divisions, of which the intermarrying laws and the descent of the progeny will be easily understood from the accompanying table and explanatory letterpress.

TABLE VII.

Phratry.	Husband.	Wife.	Son.	Daughter.
A	Mukkungurra	Kilpungurraga	Kilpungurra	Kilpungurraga
B	Kilpungurra	Mukkungurraga	Mukkungurra	Mukkungurraga

The feminine form of the divisions is distinguished from the masculine by the suffix *ga*. A Mukkungurra usually marries a Kilpungurraga, as in the above table and the resulting offspring are Kilpungurra and Kilpungurraga. In such case a man's son's child marries a sister's son's child. But if a Mukkungurra takes a Mukkungurraga as his conjugal mate, that represents the marriage of a man's son's child with a sister's daughter's child. This conclusively demonstrates that there is no exogamy among the Barkunjee people.

Every man woman and child bears the name of some animal, plant or natural object as his or her totem, which is in all cases inherited from the female parent. There is a further partition of the people into Muggulu and Ngipuru, meaning sluggish blood and swift blood. A Muggula may belong to either phratry and a Ngipuru individual has the same scope. That is, these "blood" divisions, like the totems, are dispersed indiscriminately throughout the tribal territory.

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[1] This Journal, xxxii., pp. 233 - 250.

A man of the Muggulu blood and the Butt shade usually marries a Ngipuru woman of the Branch shade, but this is subject to some irregularities. In regard to the offspring, a Muggulu mother produces Muggulu children, who take their mother's Butt shade; a Ngipuru woman produces Ngipuru children, belonging to the Branch shade. Moreover, the children take the mother's totem.

Intermarriages of individuals of the same totem are forbidden. When a Kilpungurra marries a Mukkungurraga there is no risk of conflict with the totemic regulations. If a Kilpungurra man, however, could mate with any Kilpungurraga, it would be possible for the parties to belong to the same totem; but a Kilpungurraga of the proper lineage could not possibly be of the same "blood caste" as the man.

As an evidence of the importance attached to the "blood" divisions, they are brought into prominence at the scarring of the bodies of the young men during the initiation ceremonies. A Muggulu youth has his shoulders and chest marked with shorter scars, whilst a Ngipuru youth has longer scars, to distinguish one from the other. See my "Mumbirbirri or Scarring the Body."[1]

My remarks on the absence of exogamy among the Barkunjee, apply with equal cogency to all the native tribes who occupied the whole of the western half of Victoria, where the divisions are called Gurogity and Gamaty. Last year I reported certain facts respecting the intermarriages of these divisions, which render exogamy absolutely impossible.[2]

CONCLUSION.

I have elsewhere stated that whether there are two, or four, or eight divisions of the entire community, the principles which regulate marriage and descent among the

[1] This Journal, XXXVIII, pp. 262, *seq.* [2] *Loc. cit.*, pp. 290 and 295.

divisions are identical in them all.[1] I shall endeavour to briefly place an outline of this identity before the reader.

We have seen that the Barkunjee people possess only two divisions or phratries, Table VII. A man of phratry A marries a woman of phratry B. It is also apparent that the men of phratry A, for example, can take their wives from either phratry. This amounts to the statement that the aggregate of men in phratry A can marry all the women in the community.

Next, taking the Wongaibon tribe, Table VI., we find that the two sections, Murri and Kubbi, if taken together, are equal to Mukkungurra of the Barkunjee, and Ippai and Kumbo together represent Kilpungurra. Murri and Kubbi taken jointly marry Butha and Ippatha taken jointly in one phratry. But Murri and Kubbi can jointly marry Matha and Kubbitha taken jointly in the other phratry, which is equal to Mukkungurra espousing Mukkungurraga in the Barkunjee. A little consideration shows us that the Murris and Kubbis taken collectively can marry into the whole four sections of the community.

We now come to the Wombaia divisions, Table I., which on account of their number will occupy a little more space to describe. Choolum and Cheenum, taken together as one person, represent Murri. They marry Ningulum and Nooralum, who together represent Butha, the wife of Murri. Jamerum and Yacomary together represent Kubbi.[2] They marry Palyareenya and Bungareenya, the daughters of Ningulum and Nooralum, who represent Ippatha, the daughter of Butha and wife of Kubbi. That is, Choolum, Cheenum, Jamerum and Yacomary, collectively, marry all the women in phratry A of Table I., the same as Murri

[1] *Bull. Soc. d' Anthrop. de Paris*, tome II., Serie V., (1901) p. 415.

[2] These equivalents are only assumed, for the sake of comparison.

and Kubbi marry all the women of a phratry in the Wongaibon tribe, Table VI.

But Choolum and Cheenum, the equivalent of Murri, can also marry Noolum and Neenum the equivalent of Matha. Jamerum and Yacomary, the equivalent of Kubbi, can marry Yacomareenya and Neomarum the equivalent of Kubbitha. That is, Choolum, Cheenum, Jamerum and Yacomary, collectively, can marry all the women in phratry B, the same as Murri and Kubbi can marry all the women of the other phratry in the Wongaibon. Examination of Table I. will show that Choolum, Cheenum, Jamerum and Yacomary, taken in the aggregate, can not only marry all the women in either phratry, but they can intermarry with the whole eight sections of the Wombaia community, Table I., the same as Murri and Kubbi can marry into all the four sections of the Wongaibon.

The four preceding paragraphs may be recapitulated as follows: In the Barkunjee community, a single division, Mukkungurra, represents phratry A. In the Wongaibon tribe, two divisions, Murri and Kubbi constitute phratry A. Among the Wombaia people the four divisions Choolum, Cheenum, Jamerum and Yacomary form phratry A. My examples have all been from one phratry because the same rules apply to both. In all these tribes the women are divided into two primary cycles, groups, phratries, moieties, classes, or whatever name we may employ to distinguish the divisions. It is also manifest that the name of the cycle or phratry to which the progeny belongs is in all cases established through the women, altogether irrespectively of the divisional name of the father.

Perhaps I should state here that in 1898 I described the sociology of the Dippil and other tribes[1] spread over the region lying between the northern boundary of New South

[1] *Proc. Amer. Philos. Soc.*, Phila., XXXVII., pp. 327–336, with maps.

Wales and the 19th parallel of south latitude which represents more than half of Queensland, which I delineated on a map. In that article I stated that a man of the Barrang section could marry a Barrang woman, a fact which disproves the existence of exogamy in that part of Queensland. In treating the tribes of Cape York Peninsula in 1900 I gave examples of a man marrying into both phratries.[1] Since that time in dealing with the sociology of the Murawarri, Baddyeri and Inchalanchee tribes, reaching from the New South Wales boundary to the Gulf of Carpentaria, I reported some intermarrying laws which are altogether opposed to exogamy.

All the particulars contained in this treatise respecting the Wongaibon and Barkunjee tribes have been collected by myself from the natives personally. My information regarding the Wombaia tribe has been obtained with the aid of trustworthy correspondents who have resided in that part of the country for many years. I have adopted none of the opinions nor followed any of the methods of other Australian authors, but have struck out on my own lines. The present article is necessarily very brief, but it is believed that it will shed much new light on the social organisation of the aboriginal tribes of Central Australia, New South Wales, Victoria and Queensland, and enable investigators to make a fresh start.

Spencer and Gillen,[2] have given a table of the eight divisions of the Umbaia (Wombaia) tribe, which cannot possibly represent any practical partition of the sections into cycles, phratries, or moieties. They erroneously state that descent of the sections is through the men, and they are altogether mistaken in asserting that the community is divided into "two exogamous groups."

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[1] This Journal, xxxiv., p. 132.

[2] "Northern Tribes of Central Australia," (London, 1904), pp. 70 and 100.

Dr. A. W. Howitt[1] states that "all Australian tribes are divided into two moieties, each of which is forbidden to marry within itself." He is also in error in speaking of "the segmentation of the community into two exogamous moieties."

Having studied the question of Australian sociology for many years, I am forced to the conclusion that neither promiscuous intercourse of the sexes nor what has been called "group marriage" has ever existed among the social institutions of the aborigines of Australia.[2] I am equally convinced that the divisions into cycles, phratries and sections have not been deliberately formulated with intent to prevent consanguineous marriages and incest, but have been developed in accordance with surrounding circumstances and conditions of life. This important division of the subject will receive full attention in a future treatise.

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[1] "Native Tribes of South-east Australia," (London, 1904) pp. 88 and 284.

[2] "Les Indigènes d'Australie," *L' Anthropologie*, (Paris, 1902) XIII., p. 240.

On an UNDESCRIBED SPECIES of LEPTOSPERMUM and its ESSENTIAL OIL.

By Richard T. Baker, F.L.S., Curator, and Henry G. Smith, F.C.S., Assistant Curator, Technological Museum, Sydney.

[With Plate II.]

[*Read before the Royal Society of N. S. Wales, December 6, 1905.*]

The Lemon Scented Leptospermum.

Leptospermum Liversidgei, sp. nov.

A shrub 6 to 12 feet high, glabrous, with erect numerous branches and branchlets, the lower branchlets *being quite filiform* and having persistent leaves only on the upper part. Leaves flat, concave and slightly curved, 2 to 3 lines long, very numerous and imbricate, sessile or with a very short petiole, mostly lanceolate but also ovate, rather thin, 1 to 3 nerved but not always clearly shown. Oil glands numerous and distinctly marked. Flowers solitary, axilliary on the branchlets, on a short pedicel, measuring about 6 to 8 lines in diameter when expanded. Calyx quite glabrous, broadly campanulate, lobes rounded, as long as the tube, thickened in the middle. Petals orbicular, spreading, much larger than the calyx lobes, about 2 lines in diameter, faintly veined. Ovary five-celled, flat on the top with a slight depression round the base of the pistil and a circular ridge near the free edge of the calyx. Capsule domed above the distinct flange of the calyx, 2 to 3 lines in diameter.

Habitat—Ballina (D. W. Munro), Byron Bay (J. H. Maiden and J. L. Boorman), Port Macquarie (all New South Wales localities).

L. Liversidgei, apart from its chemical constituents, has marked points of difference from cognate species. It was at first thought to be one of the many varieties of *L. flavescens* on account of its glabrous calyx, a common feature of all the species placed systematically with that "tea" tree, but the shape and disposition of the leaves, branchlets, size of the flower and chemical constituents of the oil are facts that we considered to be of sufficient importance to justify its differentiation from that species. Typical *L. flavescens* has an extensive range in the coast districts of all the eastern States of the continent, and exhibits a marked constancy of specific characters throughout its distribution especially in the shape of the leaves, which as stated by Smith in his original description,[1] "are linear, lanceolate, obtuse and nerveless,"—a description that does not apply to the leaves of this species, which apart from the other features quoted, may be said to be imbricate whilst those of Smith's plant are loose and spreading. Bentham (B.Fl. iii., p. 104-5) gives a number of species and varieties under *L. flavescens*, classifying them as:—

(a.) *commune*—This includes Smith's specimen (regarded as type) and one or two other species of different authorities.

(b.) *obovatum*—With this variety are synonymised Sweet's *L. obovatum* and Miquel's *L. micromyrtus*. This is a plant more nearly approaching var. *microphyllum*, having divaricate branches but distinct ovate leaves which are flat and not recurved, and are much larger than those of that var. or this new species.

(c.) *grandiflorum*—Under this are placed *L. grandiflorum*, Lodd., *L. virgatum*, Schau., *L. nobile*, F.v.M. The leaves, flowers and fruits of this var. are longer and finer than those of this new species and not so numerous and differently shaped.

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[1] *Trans. Linn. Soc.*, III., p. 262.

(d.) *microphyllum*—It was at first thought that *L. Liversidgei* might be this variety, and was so named by us at first, but a further investigation showed this determination to be wrong. This variety is a robust shrub with stout, divaricate or dichotomous branchlets with leaves drying a light grey colour and the whole plant resembling somewhat a small variety of *L. lævigatum* with scattered leaves, a marked contrast to the erect branches with very numerous very fine slender filiform branchlets of this new species which has also less numerous, more distant and differently shaped leaves.

(e) *minutifolium*, of F.v.M.—This is altogether a different form from this new one, having distinctly channelled recurved leaves, smaller and differently shaped to those of *L. Liversidgei.* It has also stouter branchlets and never the slender filiform ones of the latter species, and its leaves are distinctly 3-nerved, whilst the flowers show good characteristic differences, are much smaller, and the petals being more deciduous.

L. scoparium, Forst. and *L. arachnoideum*, Sm., have each a glabrous calyx, and that is their only resemblance to this species.

Essential Oil.

The lemon odour which this plant gave when the leaves were crushed, was considered to be an indication of the possible presence of citral, and as the results promised to be of an interesting nature, a quantity of material was obtained for distillation. The material was collected several days before it reached the Museum, and the leaves had, by that time, become so loosely attached to the stem that they easily fell off when the twigs were shaken. The leaves of this plant are very small, and as they so readily fall off it would be desirable to distil the plant soon after collecting. The twigs and woody portion were present in larger amount

than would be necessary for commercial distillation, so that the yield of oil as here given, is perhaps a little less than would be obtained commercially, particularly if care were taken in the collection of the material.

The amount of oil obtained from 373 pounds of leaves and branchlets was 13½ ounces, equal to 0·227%. The crude oil was somewhat mobile and had a marked secondary odour of citral; it was reddish-brown in colour, but this, being due to the mode of distillation, was accidental. The red colour was entirely removed by agitating the oil with a very dilute solution of aqueous potash or soda; after this treatment the oil was of a light lemon tint.

The principal constituents in the oil were, (1) the aldehyde citral, (2) an alcohol considered to be geraniol, (3) an acetic acid ester considered to be geranyl-acetate, (4) the terpene pinene which was dextrorotatory, and (5) a sesquiterpene, which is probably the constituent which gives the lævo-rotation to the higher boiling portion. Limonene could not be detected by any method, and was, therefore, absent; nor was phellandrene present. The whole of the aldehyde appears to be citral, as proof of the presence of any other aldehyde could not be obtained, and two determinations by Flatau and Labbe's method failed to give any indication for citronellal. The physical determinations seem also to indicate that citral is alone present. The secondary odour of the oil, from which the aldehydes had been removed, strongly resembled that of geraniol. The oils of the Leptospermums do not appear to have been chemically investigated, so that the occurrence of citral in the oil of *Leptospermum Liversidgei* is of some scientific interest.

EXPERIMENTAL.

The crude oil was insoluble in 10 volumes 70% alcohol (by weight) but was soluble in 1 volume 80% alcohol. The rotation in 100 mm. tube was $a_D + 9·2°$. The refractive

index at 16° C. was 1·4903. The specific gravity at 15° C. was 0·8895. On a first rectification three main divisions were detected, but owing to the presence of such a large proportion of high boiling constituents the lower boiling portion was not readily separated. Below 170° C. 20% distilled; the specific gravity at 15° C. of this fraction was 0·8624, the refractive index 1·4774 at 16° C., and the rotation in 100 mm. tube a_D + 32·5°. Between 195 – 225° C. 30% distilled; the rotation of this fraction was + 5·7°; the specific gravity 0·8892, and the refractive index 1·4892. Between 225 – 235° C. 20% distilled, this fraction was lævorotatory, the rotation being – 1·1°; the specific gravity was 0·9048, and the refractive index 1·4945. Between 235 – 273° C. 12% distilled, which consisted largely of a sesquiterpene, the refractive index of this fraction was 1·5052 and the specific gravity 0·9024; the rotation could not be well taken, but it was lævorotatory. The indications thus pointed to the presence of pinene, of a large proportion of alcohols or aldehydes, of a sesquiterpene and perhaps esters.

The first fraction was again distilled, and the portion boiling at 155 – 157° C. was collected apart. This was shown to be dextrorotatory pinene. The specific gravity when cooled to 15° C. was 0·8601; the refractive index at 20° C. was 1·4706, and the rotation a_D + 35·5°. The nitrosochloride was also prepared and this melted at near 103° C. When the oil distilling between 170 – 195° C. was rectified pinene was again obtained. It is thus assumed that about 25% of the oil was pinene. When the oil was treated with twice the volume of a 30% solution of sodium bisulphite a solid mass soon formed, the aldehydic portion readily dissolved when heated in the water bath. Two closely agreeing determinations by this method, in the ordinary way, gave a mean yield of 35% of aldehydes. The aldehydic

constituents were also removed from a larger quantity of oil prepared for the other determinations, and the separated oil carefully collected and weighed; 40 grams of oil gave 25·9 grams of non-aldehydic constituents, equal to 35·25% of aldehydes. The barium salt of the aldehydic bisulphite compound was prepared, and the aldehyde when separated from the filtrate by the addition of soda, extracted by ether and steam distilled, was shown to be citral. Its odour indicated that aldehyde, its specific gravity at 21° C. was 0·8929 and it had a refractive index 1·4913 at 20° C., it was also inactive to light, and the naphthocinchoninic acid, prepared by Doebner's reaction, melted at 199° C. The very small amount of aldehyde (about one per cent.) obtained from the barium precipitate in the usual way, gave no indication for citronellal, but consisted apparently of partly polymerised citral as indicated by the odour and by the refractive index.

The citral prepared from the crystalline bisulphite compound by purifying the crystals with ether-alcohol, decomposing with sodium carbonate and steam distilling, gave at 20° C. a refractive index 1·4913 and specific gravity 0·8937, indicating that citral is the only aldehyde present.

The non-aldehydic portion of the oil had a specific gravity 0·8866 at 20° C.; rotation + 13·4°; refractive index 1·4855 at 22° C. The index of the original oil determined at the same time and under identical conditions was 1·4873, so that the index of the aldehyde was higher than that figure. The ester determination was made on the non-aldehydic portion of the oil, the saponification number was 23·5 equal, to 8·225% of ester as geranyl-acetate. The aldehyde being 35%, this gives 5·346% of ester in the original oil. A determination for ester in the crude oil gave 5·54%. A portion of the non-aldehydic oil was esterised in the usual way, and this gave a saponification number 73·63, which repre-

sented 14·98% of free alcohol, or 9·74% of geraniol in the original oil.

The oil of *Leptospermum Liversidgei* may be stated to have approximately the following composition :—

Citral	35·00	per cent.
Geranyl-acetate	5·35	„
Free Geraniol	9·74	„
Dextro-pinene	25·00	„
Sesquiterpene and undetermined	24·91	„
	100·00	

This species is dedicated to Prof. A. Liversidge, M.A., LL.D., F.R.S., of the Sydney University, and twice President of our Society, as a slight recognition of his efforts in the furtherance of industrial science in Australia. It was due largely to his efforts that the Technological Museum, Sydney, was established, and as one of the original Committee of Management he was ever enthusiastic in its development, and is always ready to place his mature experience at the disposal of its officers.

We have to acknowledge our indebtedness to Mr. J. H. Maiden, F.L.S., for his kindness in allowing us the use of the Leptospermums of the National Herbarium for comparative purposes, and also to Mr. E. G. Duffus, Secretary for Agriculture, Melbourne, and Mr. J. R. Tovey, the officer in charge of the Victorian Herbarium, for similar favours.

Explanation of Plate

1. Flowering twig. 2. Bud. 3. Bud partially expanded. 4. Expanded flower. 5. Horizontal section of flower. 6. Spray with fruits. (2, 3, 4, 5, enlarged.)

NOTE ON A HOLLOW LIGHTNING CONDUCTOR CRUSHED BY THE DISCHARGE.

By J. A. POLLOCK, Professor of Physics,
and
S. H. BARRACLOUGH, Lecturer in Mechanical Engineering in the University of Sydney.

[With Plate III.]

[*Read before the Royal Society of N. S. Wales, December 6, 1905.*]

THE piece of lightning conductor to which this note refers was submitted to us by Mr. G. H. Clark of Sydney. It consists of a tube originally cylindrical, 17·5 cms. long, the outer diameter being 1·8 cms., made of copper 0·1 cm. thick with a lap joint 0·4 cm. wide where the thickness is 0·2 cm. The piece was the upper portion of a pipe 135 cms. long, connecting the finial with a copper band running down a chimney. The specimen, photographs of which are given in *Plate* III., is crushed in a symmetrical manner and shews the characteristic appearance of a tube which has collapsed under external pressure.

The crushing is probably due to the electrodynamic action of the current. On this assumption if the stress at which the tube gave way was known, one could obtain some knowledge of the current during the discharge. For the tube under consideration, a calculation, particulars of which are given below, shows that the mechanical effect at any moment due to the current measured in ampères is equivalent to an excess of hydrostatic pressure on the outside of the tube of n atmospheres, where

$$I = 22000 \sqrt{n}$$

I_0 being the total current in the conductor at the given moment.

For reasons given later, we believe that the material of the tube was probably plastic at the time of collapse, owing to the heat developed by the discharge. If this is so, the pressure required to produce the observed folding at any assumed temperature, cannot be calculated; the theory applicable to such a case and the data of the mechanical properties of copper at the high temperatures here contemplated are alike wanting. Possibly the material was in such a state that the tube gave way under forces equivalent to an excess of pressure outside of the order of not more than an atmosphere; this would indicate a current of about 20,000 ampères, neglecting any consideration of the oscillatory character of the discharge.

On the other hand if the material was not plastic, assuming a temperature as low as 500° C. at the time of crushing we estimate that the collapsing pressure would be of the order of 400 lbs. per sq. inch; forces equivalent to such a pressure would be produced by a current of about 100,000 ampères.

To illustrate the action of the current suggested above, extremely thin tubes were made by depositing copper electrolytically on silvered glass rods. The ends of the tubes were thickened and the glass rods afterwards removed. On passing a current along the tubes, at a red heat they showed definite signs of collapse though not the characteristic folding exhibited by the piece of lightning conductor. In the Report of the Lightning Rod Conference (Spon 1882) on p. 214, a detailed account is given of a hollow conductor which had been struck by lightning, but no mention is made of any appearance of collapse. The tube was however stiffer than the one submitted to us, the external diameter being 1·27 cms. as against 1·8 cm. and the smallest thickness 0·16 cms. as against 0·10 cm.

Description of the Conductor.

Fig. 1 is a sketch to scale of the upper portion of the lightning conductor, the parts drawn in continuous lines shewing the pieces which have been preserved. *a b* represents the pipe, whose dimensions have been already given. At *a* and *b* the pipe was sweated on to solid rods, the upper one being attached to the ball and the lower one to a right angled piece to which the main conductor was attached. The folding is most pronounced at *b* just below the end of the solid rod; it is not quite symmetrical as the pipe is stiffer at the lap joint. Folding is also shown at *a* just above the end of the solid rod; at this point the pipe was fused. The greater portion of the pipe from c to *a* was unaltered in shape, its section remaining circular. After the fusion at *a* the lower part of the conductor fell away but the pipe remained vertical throughout its length, attached to the chimney by the two holdfasts shown. Photographs of the part *b c* are given in *Plate* III., and the diagrams *B* and *C* (fig. 1) represent enlarged sections of the conductor on the lines *b* and *c* respectively.

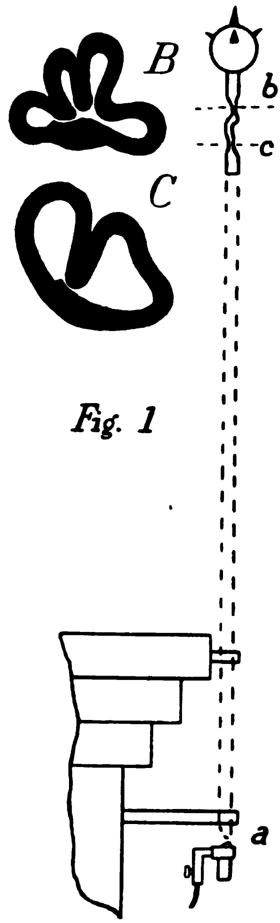

Fig. 1

The surface of the upper part of the tube is covered with little pit marks from about 0·1 to 0·5 mm. in diameter and 0·02 mm. deep. We are unable to say whether these marks

are due to the heating of the pipe by the discharge or to weathering. Probably the upper part of the tube which has collapsed was raised to a higher temperature than the rest of the pipe as it formed portion of the end of the electrode where the development of heat is always considerable. The tube as shown in one of the photographs (*Plate* III.) has apparently buckled as a column under the small weight of the ball ($3\frac{1}{2}$ lbs.), allowing the latter to subside vertically. This would indicate that the material at this point was in a plastic condition.

It is probable that the fusion at *a* figure 1 was due to an arc which occurred on account of the right angled bend in the conductor, and it is not to be considered as indicating more than a very local high temperature. On this view one should perhaps expect that the signs of fusion would appear in the right angled piece shown to the left of the tube in figure 1; the only signs of fusion however are found to the right of the tube on the outer edge of the collar.

Mr. G. H. Clark under whose supervision the conductor was erected, supplies the following particulars:—"The conductor was erected in 1889 on the chimney stack of the Hartley Vale Kerosene Refinery. The finial, which stood about 3 ft. above the cap of the chimney, consisted of a gun metal ball $3\frac{1}{2}$ inches in diameter, having one large centre point and four smaller radiating ones. The weight of the ball was about $3\frac{1}{2}$ lbs. The copper pipe connected the finial with a somewhat massive copper goose neck just below the cap of the chimney, which was attached to the conductor, consisting of a copper band $1 \times \frac{1}{8}$ inch. From the base of the chimney the conductor was run in a trench 18 inches deep some 30 feet, thence into a well 30 ft. deep, the band terminating in a grid, of $1 \times \frac{1}{8}$ inch copper, $2\frac{1}{2} \times 2\frac{1}{2}$ feet. This well supplied the works boiler with water; when the water became foul with the soakage from the Refinery it was usual to blow it out clean with a jet of

steam; this was being done when the storm occurred, the grid being suspended in the well, free from the bottom. From what I could gather at the time, some ten years ago, there appears to have been only one severe flash. The central point on the ball and two of the radiating ones were cut off and the pipe was fused at the goose-neck which connected it with the copper band. This was the only damage sustained. The copper band for a distance of 20 feet below the goose neck was tempered to a hardness of a steel band, so much so that in repairing the conductor, it was with some difficulty that the gun metal holdfasts could be made to hold, though these were driven into lead plugs and well caulked. When a holdfast was put in and the band struck to get the buckle out, one or two above would be sprung out of the plugs."

ELECTRODYNAMIC ACTION OF THE CURRENT.

For steady currents uniformly distributed over the area of cross section, elementary considerations show, in the case of a solid cylinder of radius a, that the sum of the mechanical forces acting throughout the matter contained in unit length of the cylinder is given by the expression $4\,I_0^2/3a$ where I_0 is the total current flowing along the conductor, the forces at all points being directed radially inwards in planes at right angles to the axis of the cylinder. Under the same circumstances, for a cylindrical shell of inner radius b and outer radius a, the corresponding expression is $4\,I_0^2\,(a+2b)/3\,(a+b)^2$, which if the shell is very thin reduces to I_0^2/a. With alternating currents for a cylindrical conductor where a is the radius of the outer surface, J. J. Thomson "Recent Researches," § 268, gives as the maximum value of the magnetic force at a point in the cross section fixed by a radius r

$$\frac{2}{\sqrt{ar}}\, I_0 e^{-\beta\,(a-r)}$$

where I_0 is the total current flowing along the conductor

and $\beta = (2\pi\mu p/\sigma)^{\frac{1}{2}}$, $p/2\pi$ being the frequency of the current alternations, μ the magnetic permeability and σ the specific resistance of the material of the conductor.

The maximum current flowing along a cylindrical shell of the conductor of radius r and of thickness dr is:—

$$I_0 e^{-\beta(a-r)}\left[\beta\sqrt{\frac{r}{a}} + \frac{1}{2\sqrt{ar}}\right] dr$$

The maximum value of the sum of the mechanical forces on unit length of such a shell is given by the product of the above expressions. For unit length of a cylindrical tube, of inner radius b and outer radius a, the product becomes:—

$$\frac{2\beta}{a} I_0^2 e^{-2\beta a}\int_b^a e^{2\beta r}\,dr + \frac{I_0^2}{a} e^{-2\beta a}\int_b^a \frac{1}{r} e^{2\beta r}\,dr$$

The value of the first term is:—

$$\frac{I_0^2}{a}\left(1 - e^{-2\beta(a-b)}\right)$$

and that of the second lies between

$$\frac{I_0^2}{a}\log\frac{a}{b} \text{ and } \frac{I_0^2}{a}\log\frac{a}{b}\, e^{-2\beta(a-b)}$$

For copper $\mu = 1$ and σ may be taken as 1,600. If we assume that the frequency of alternation in the discharge is 10^6 per sec. then β or $(2\pi\mu p/\sigma)^{\frac{1}{2}} = 50\pi$. With these values and as in the case of the tube under consideration a/b differs little from unity, no term in the expression for the product except the first is of importance, and the maximum value of the sum of the forces acting radially inwards on unit length of the cylindrical tube may be written

$$\frac{I_0^2}{a}$$

or the force per unit area $\dfrac{I_0^2}{2\pi a^2}$

Where a = 0·9 cms. the force in dynes per square centimetre will be given by $\frac{I_0^2}{500}$ where I_0 is measured in ampères.

If the pressure of an atmosphere is taken as equal to 10^6 dynes per sq. cm. a current I_0 measured in ampères will produce an effect equivalent to that of an external pressure of n atmospheres if $n = \frac{I_0^2}{500 \times 10^6}$ or $I_0 = 22000 \times \sqrt{n}$.

Mechanical Considerations.

It is desired to estimate the pressure at which the tube under discussion collapsed; such an estimation is difficult to make with any accuracy, because:—

a. The condition of the tube and the quality of the metal are not known.

b. The temperature of the metal at the moment of its collapse is quite unknown, and there are very few circumstances to guide one in estimating it, and

c. The theory of the collapse of tubes is imperfect.

Obviously all that can be done is to obtain approximate upper and lower limits of the pressure conditions at the time.

a. The material of which the tube was made would probably have a tensile strength of about 30,000 lbs. per square inch at ordinary temperatures, and an elastic limit of approximately 5,500 lbs. per square inch. Copper has no definite "compressive strength" properly so called, but there is a fairly well marked elastic limit in compression at about 3,500 lbs. per square inch. These figures decrease to a marked degree with increase of temperature; the tensile strength for example being reduced to approximately 20,000 lbs. per square inch at a temperature of 600° Fahr. Copper melts at a temperature of about 1,930°Fahr.(1054°C.) but experiments on the strength of copper with varying temperatures have not been carried beyond 1,100° Fahr.[1]

[1] The Effect of Temperature on the Tensile and Compressive Properties of Copper.—This Journal Vol. xxxi.

b. The above figures would apply if it were assumed that the tube at the moment of collapse was at the ordinary temperature. It is not probable that such was the case, and the temperature may obviously have been anything up to a limit just short of melting. The appearance of the collapsed tube would not lead one to suppose that the metal had reached the neighbourhood of its point of fusion, and this view is confirmed by the fact that the solder connecting the tube to the solid rod above does not appear to have been melted to any marked degree, if at all. It is obvious therefore that the temperature of the material at the time of collapse is a matter of speculation.

c. A large number of experiments have been made on the pressures necessary to produce collapse in tubes, of which the best known are those by Sir W. Fairbairn,[1] who carried out an elaborate series on tubes and boiler flues. None of the tubes were as small as that now under consideration, but the results indicate generally the action of the tubes when subject to external pressure. Professor Unwin made a fresh analysis of the results obtained by Fairbairn, and deduced several semi-empirical equations to represent the collapsing pressure under various conditions.[2] He also demonstrated clearly that the number of lobes into which the tube collapses depends on the ratio of the length to the diameter, increasing in a definite fashion as this ratio decreases. An illustration of this fact is seen in the tube under consideration, where at the end near the junction of the tube and the solid rod the conditions of a tube of short length compared with its diameter are approximated to, and where the number of lobes is large, while further down where the long-tube conditions obtain, the number of lobes is reduced to the minimum. The conditions of the tube are so indeterminate that it is unnecessary to discuss the formulæ in detail.

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[1] Phil. Trans, 1858. [2] Proc. Inst. C. E., Vol. XLVI.

OBITUARY NOTICE.

CAPTAIN HUTTON, F.R.S.

CAPTAIN FREDERICK WOLLASTON HUTTON, F.R.S., F.G.S., C.M.Z.S., was at his death one of our oldest surviving Hon. Members, having been elected in 1888; those senior to him are but two, viz.: Sir JOSEPH HOOKER, G.C.S.I., elected in 1880, and Sir M. FOSTER, K.C.B., 1887. Captain HUTTON was the second son of the Reverend H. F. HUTTON, Rector of Spridlington and was born at Gate Burton, Lincolnshire, England, November 16th, 1836, he was educated at Southwell Grammar School and the Naval Academy at Gosport. After leaving Gosport he spent three years in the India Mercantile Marine, being over age for the Royal Navy; he then entered the army and served with the 23rd Royal Welsh Fusiliers in the Crimea in 1855-6, later he took part under Sir COLIN CAMPBELL in the relief and capture of Lucknow in 1857 and the defeat of the Gwalior mutineers, for which he received the medal and two clasps. On his return home he entered the Staff College, where he studied geology under Prof. RUPERT JONES; his career was a distinguished one, and he passed out as sixth on the list in 1860. In 1862 he was gazetted Captain and served as Deputy Assistant Quartermaster-General at Dublin.

In 1866 he went out to New Zealand, and in 1871 was appointed Assistant Geologist to the New Zealand Survey, Curator of the Otago Museum in 1873 and Professor of Natural Science in the University of Otago 1887. In 1880 he was appointed to the Professorship of Biology at Canterbury College, Christchurch: in 1893 he resigned the chair to become Curator of the Canterbury Museum. He was

elected a Corresponding Member of the Zoological Society in 1872. He was a Corresponding Member of the Royal Society of Tasmania, Correspondent du Mus d'Histoire Nat. Paris; Academy of Natural Science, Philadelphia; Ornith. Ver. Wien and K. K. Geol. Reichsanst. Wien. In 1891 he was awarded the Clarke Memorial Medal by the Royal Society of New South Wales for meritorious contributions to the Geology of Australasia. In 1892 he was elected F.R.S.; he was President of the Australian Association for the Advancement of Science at the Hobart Meeting 1902, and was President of the New Zealand Institute at the time of his death, which took place on October 27th last, on board the R.M.S. *Rimutaka* when returning from England to New Zealand.

He took a leading part in the scientific life both at Dunedin and at Christchurch, and his influence was felt not only over New Zealand and Australia, but throughout the scientific world. He was the author of a large number of valuable papers on the geology, botany and zoology of New Zealand and other subjects, he was also a frequent and valued contributor to "Nature"; his last contribution appeared in it a month or two before his death. I do not attempt to notice his work in detail, as I think that should be done by one specially qualified in the subjects to which our late colleague devoted himself.

One of his first papers was an essay upon the "Importance of a knowledge of geology to military men" published in the Journal of the Royal United Service Institution in 1862. Many of his papers were published in the Transactions of the New Zealand Institute, the Proceedings of the Linnean Society of New South Wales, the Proceedings of the Zoological Society, the Ibis, the Geological Magazine, and the Reports of the Australasian Association for the Advancement of Science. In the Royal Society's List of

Scientific Papers there are 133 entries under his name, from 1862 to 1884 (the date of the last published vol.) but numerous other papers have since been published by him. As shown by his published papers and addresses, from his subaltern days onwards, he was deeply interested in the subject of evolution; in 1899 appeared "Darwinism and Lamarckism Old and New," in 1902 "The Lesson of Evolution." In addition to the more purely scientific papers he published a Class Book of Elementary Geology 1875, and in association with JAMES DRUMMOND "Nature in New Zealand" 1903, and "The Animals of New Zealand" 1904. A short paper upon "What is Life?" written by him during his visit home, appeared in the November number of Hibbert's Journal.

The following extract from the "Life and Letters of Charles Darwin" will give an idea of what two of our greatest men of science thought of HUTTON'S scientific judgment at a time when he was only 25 years of age. In writing to JOSEPH HOOKER, DARWIN says:—"I quite agree with what you say on Lieutenant HUTTON'S review in the "Geologist," (on Darwin's "Origin of Species," 1861, p. 132), who he is I know not; it struck me as very original. He is one of the very few who see that the change of species cannot be directly proved, and that the doctrine must sink or swim according as it groups and explains phenomena. It is curious to see how few judge it in this way, which is clearly the right way."

Captain HUTTON was an ardent worker and observer and was ever ready to give a generous support to the efforts of others; a close reasoner, of clear and independent thought, a pleasant companion and a loyal friend. He greatly disliked publicity, he had a soldier's directness and simplicity of purpose and a strong abhorrence of anything in the nature of pretentions or shams.

December, 1905. A. LIVERSIDGE.

ABSTRACT OF PROCEEDINGS

a—May 3, 1905.

ABSTRACT OF PROCEEDINGS

OF THE

Royal Society of New South Wales.

ABSTRACT OF PROCEEDINGS, MAY 3, 1905.

The Annual General Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, May 3rd, 1905.

Prof. LIVERSIDGE, M.A., LL.D., F.R.S., Vice-President, in the Chair.

Thirty-seven members and three visitors were present.

The minutes of the preceding meeting were read and confirmed.

The following Financial Statement for the year ended 31st March, 1905, was presented by the Hon. Treasurer, and adopted:—

GENERAL ACCOUNT.

	RECEIPTS.	£ s. d.	£ s. d.
Subscriptions	One Guinea	68 5 0	
	„ „ Arrears	11 14 0	
	Two Guineas	369 12 0	
	„ „ Arrears	99 11 0	
	Advances	4 4 0	
			553 6 0
Composition for Life Membership			10 10 0
Parliamentary Grant on Subscriptions received—			
Vote for 1904-1905		250 0 0	
			250 0 0
Rent			81 5 0
Sundries			20 11 4
Clarke Memorial Fund			250 0 0
Total Receipts			1165 12 4
Balance on 1st April, 1904			10 15 10
			£1176 8 2

N.B.—The Outstanding Accounts amount to £125 2s. 1d.

Payments.	£ s. d.	£ s. d.
Advertisements	19 3 0	
Assistant Secretary	250 0 0	
Books and Periodicals	54 3 3	
Bookbinding	3 19 6	
Collector	3 7 2	
Expenses at Meetings	26 1 6	
Freight, Charges, Packing, &c....	4 0 11	
Furniture and Effects	1 4 7	
Gas	18 9 3	
Housekeeper	10 0 0	
Insurance	9 7 8	
Interest on Mortgage	42 0 0	
Office Boy	24 7 6	
Petty Cash Expenses	8 13 4	
Postage and Duty Stamps	24 15 0	
Printing	29 18 0	
Printing and Publishing Journal	269 19 0	
Printing Extra Copies of Papers	9 9 6	
Rates	41 3 6	
Repairs	0 11 9	
Stationery	19 10 9	
Sundries	22 14 5	
Total Payments		892 19 7
Building and Investment Fund, Composition for Life Membership		10 10 0
Clarke Memorial Fund—Loan repaid	250 0 0	
Interest to date	3 10 0	
		253 10 0
Bank Charges		2 18 7
Balance on 31st March, 1905, viz.:—		
Cash in Union Bank...	6 10 0	
Cash in hand...	10 0 0	
		16 10 0
		£1176 8 2

BUILDING AND INVESTMENT FUND.

Dr.	£ s. d.	£ s. d.
Loan on Mortgage at 4%		1400 0 0
Composition for Life Membership, 1902 ...	21 0 0	
Ditto, 1904-5	10 10 0	
Interest	0 11 0	
		32 1 0
		£1432 1 0

Cr.	£ s. d.	£ s. d.
Deposit in Government Savings Bank, March 31st, 1905		32 1 0
Advance to General Account 31st March, 1897	8 0 6	
Balance 31st March, 1905	1391 19 6	
		1400 0 0
		£1432 1 0

CLARKE MEMORIAL FUND.

Dr.	£ s. d.
Amount of Fund, 31st March, 1904	469 9 11
Interest to 31st March, 1905	16 4 3
	£485 14 2

Cr.	£ s. d.
Deposit in Savings Bank of New South Wales, March 31, 1905	241 8 3
Deposit in Government Savings Bank, March 31, 1905 ...	244 5 11
	£485 14 2

AUDITED AND FOUND CORRECT, AS CONTAINED IN THE BOOKS OF ACCOUNTS.

DAVID FELL, C.A.A. .... } *Honorary Auditors.*
T. TYNDALL PETERSON, A.S.I.A. }

SYDNEY, 28th April, 1905.

D. CARMENT, F.I.A., F.F.A. *Honorary Treasurer.*
W. H. WEBB. *Assistant Secretary.*

A vote of thanks was passed to the Hon. Auditors, viz., Mr. DAVID FELL, C.A.A., and Mr. T. TYNDALL PETERSON, A.S.I.A., for their services.

Dr. MARDEN, M.A., and Mr. W. A. DIXON, F.I.C., were appointed Scrutineers, and Dr. SPENCER deputed to preside at the Ballot Box.

There being no other nominations the following gentlemen were declared duly elected Officers and Members of Council for the current year:—

President:
H. A. LENEHAN, F.R.A.S.

Vice-Presidents:

Prof. LIVERSIDGE, LL.D., F.R.S.	F. B. GUTHRIE, F.I.C., F.C.S.
Prof. WARREN, M. Inst. C.E., Wh.Sc.	F. H. QUAIFE, M.A., M.D.

Hon. Treasurer:
D. CARMENT, F.I.A., F.F.A.

Hon. Secretaries:

J. H. MAIDEN, F.L.S.	G. H. KNIBBS, F.R.A.S.

Members of Council:

S. H. BARRACLOUGH, Assoc. M. Inst. C.E.	T. H. HOUGHTON, M. Inst. C.E.
Prof. T. W. E. DAVID, B.A., F.R.S.	H. C. RUSSELL, B.A., C.M.G., F.R.S.
H. DEANE, M.A., M. Inst. C.E.	HENRY G. SMITH, F.C.S.
T. F. FURBER, F.R.A.S.	WALTER SPENCER, M.D.
W. M. HAMLET, F.I.C., F.C.S.	J. STUART THOM

The certificate of one candidate was read for the third time, of one for the second time, and of six for the first time.

The following gentleman was duly elected an ordinary member of the Society, viz:—

Harker, George, D.Sc. Petersham.

Thirty-three volumes, 410 parts, 39 reports, 10 pamphlets, 1 map, and 1 atlas of charts, total 494, being portion of the donations received since the last meeting, were laid upon the table and acknowledged.

The following letter was received from Mr. L. W. MARCKER, Consul for Denmark:—

Consulate of Denmark, Sydney, N.S.W.
February 9th, 1905.

Sir,—The sympathy which has been shown by men of science from all parts of the world over the death of the young Danish scientist Professor Mils R. Finsen, and the numerous foreign enquiries which have been made, asking permission to take part in the movement started in Denmark to raise funds, according to the deceased's last wish, to enable the scientific institution called the Finsens Institute (to which Finsen presented the Nobel Prize won by him) to continue the researches, so ably begun by him, has resulted in that the original Danish Committee now has become a universal one. Sub-committees have been started in England, all over the Continent, and in America. At the request of the Danish Committee, the Consulate has received instructions from the Ministry for Foreign Affairs, Copenhagen, to place the matter before the scientific bodies in Sydney, I therefore herewith have the honour to request you

kindly to be good enough to direct the attention of the members of your honoured Society to the movement. The Consular instructions are also to give any local movement which might be started, all possible assistance, and I need hardly say, that any information or help I can give will be given with very great pleasure.

I have etc.,

L. W. MARCKER, Consul.

Messrs. J. H. Maiden and G. H. Knibbs, Hon. Secretaries,
Royal Society of N. S. Wales.

Letters were received from Mr. C. O. BURGE, M. Inst. C.E., acknowledging receipt of copy of resolution carried at the previous Council meeting. Also tendering his resignation as a member of the Society owing to his approaching departure for good from Australia.

The Chairman made the following announcements:—

1. THE BRITISH SCIENCE GUILD.—It has been a frequent subject of comment that, although the contribution of this country to the progress of science has been second to that of no other nation, the English people do not manifest that interest in, and belief in the powers of science, which are noticeable among the peoples of the Continent, or of America. In spite of the efforts of many years, the scientific spirit, essential to all true progress, is still too rare, and, indeed, is often sadly lacking in some of those who are responsible for the proper conduct of many of the nation's activities. It is with the view of attempting to remedy this evil, and to bring home to all classes the necessity of applying scientific treatment to affairs of all kinds, that the proposal is made to bring together those convinced of this necessity by founding "The British Science Guild." The objects and organization of the Guild, which will be entirely disconnected from party politics, are as follows:—(1) To bring together as members of the Guild all those throughout the Empire interested in science and scientific method, in order, by joint action, to convince the people, by means of publications and meetings, of the necessity of

applying the methods of science to all branches of human endeavour, and thus to further the progress and increase the welfare of the Empire. (2) To bring before the Government the scientific aspects of all matters affecting the national welfare. (3) To promote and extend the application of scientific principles to industrial and general purposes. (4) To promote scientific education by encouraging the support of universities and other institutions where the bounds of science are extended, or where new applications of science are devised. Methods of attaining these objects: (*a*) by publications; (*b*) by meetings; (*c*) by conferences and lectures; (*d*) by deputations. All British subjects, both men and women, are eligible for membership of the Guild. It was resolved that life members of the Guild shall pay, on admission, two guineas, which includes a registration fee of 2s. 6d., and that annual subscribers shall pay, on admission, 5s., and in each subsequent year 2s. 6d. It was also resolved that donations may be accepted.

2. The present position and prospects of the International Catalogue of Scientific Literature. His remarks will be published in the June Abstract.

3. The forthcoming meeting of the British Association for the Advancement of Science to be held at Cape Town, South Africa, commencing August 15th, 1905.

4. The death (on April 30th) of Mr. CHARLES MOORE, F.R.B.S., C.M.Z.S., the following resolution proposed by Mr. J. H. MAIDEN and seconded by Dr. F. H. QUAIFE, was duly carried, the members standing:—"That the Royal Society of New South Wales has heard with deep regret of the death of Mr. CHARLES MOORE who had been a member since the year 1856, and who for two years was its oldest member. He served on the Council continuously from the year 1868, was honorary secretary from 1871 to 1874, and vice-president for nine years, between the years 1878 and

1900. That this Society desires to convey its sympathy with the relatives of their colleague."

THE FOLLOWING PAPERS WERE READ:

1. "On the occurrence of Calcium oxalate in the barks of the Eucalypts," by HENRY G. SMITH, F.C.S., Assistant Curator, Technological Museum, Sydney.

The author announces the presence, in large quantities, of calcium oxalate in the barks of several species of Eucalyptus. It is similar in form and appearance in all species, being well defined monoclinic crystals in stout microscopic prisms, averaging 0·0174 mm. in length, and 0·0077 mm. in breadth and containing one molecule of water. A peculiarity of these is the tendency to form twins geniculate in appearance; twinned forms being pronounced in some species. From botanical and chemical evidence it is assumed that *Eucalyptus salmonophloia* of West Australia and *E. oleosa* of New South Wales belong to the same species, and that the latter tree, which most often occurs as a "Mallee," is only the degenerate stage of the former. The theory is advanced that some of the "mallees," or shrubby Eucalypts, have been formed through the poisoning effect of the excess of oxalic acid, acting for a long time upon species which originally grew as large trees. The tannins in those Eucalyptus barks containing a large amount of calcium oxalate are of very good quality, light in colour, astringent, easily soluble, and should make leather of good quality. On evaporating the extract to dryness on the water bath but little darkening takes place, and the product is still readily soluble. This class of Eucalyptus barks should, therefore, make excellent tanning extracts. From the bark residue the calcium oxalate should be profitably extracted, and the oxalic acid obtained cheaply from this, practically as a by-product. The air dried bark of *Eucalyptus salubris*, the "Gimlet" of West Australia, gives

30·5% of total extract and 18·6% of tannin absorbed by hide powder, and contains 16% of calcium oxalate. The bark of *Eucalyptus gracilis* contains 16·66% of calcium oxalate; that of *E. Behriana* 16·5%; of *E. oleosa* 10·64%; of *E. dumosa* 9·8%; and of *E. salmonophloia* 8·34%. The barks of all the Eucalypts tested contain calcium oxalate, although in some species in very small amount.

2. "Notes of astronomical interest, dealing with the past eighteen months, showing the progress and deductions made during that period," by H. A. LENEHAN, F.R.A.S., Acting Government Astronomer.

EXHIBITS.

A collection of fossil Halysites from the Orange district was exhibited by Mr. C. A. Süssmilch, F.G.S.

Prof. LIVERSIDGE vacated the Chair and Mr. H. A. LENEHAN, F.R.A.S. was installed as President for the ensuing year.

Mr. LENEHAN thanked the members for the honour conferred upon him.

ABSTRACT OF PROCEEDINGS, JUNE 7, 1905.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, June 7th, 1905.

H. A. LENEHAN, F.R.A.S., President, in the Chair.

Thirty-six members were present.

The minutes of the preceding meeting were read and confirmed.

Dr. GEORGE HARKER enrolled his name and was introduced.

Mr. T. H. HOUGHTON, M. Inst. C.E., and Mr. HENRY G. SMITH, F.C.S., were appointed Scrutineers, and Mr. W. M. HAMLET, F.I.C., F.C.S., deputed to preside at the Ballot Box.

The certificate of one candidate was read for the third time, of six for the second time, and of four for the first time.

The following gentleman was duly elected an ordinary member of the Society. viz.:—

ANDERSON CHARLES, M.A., B.Sc. Edin.; Roslyn Gardens.

Forty-seven volumes, 231 parts, 6 reports, and 10 pamphlets, total 294 received as donations, were laid upon the table and acknowledged.

The following letter was received from Miss van Heuckelum, acknowledging the receipt of a letter of sympathy on the occasion of the death of Mr. CHARLES MOORE:—

6 Queen-street, Woollahra, May 22nd, 1905.

The Hon. Secretaries, Royal Society of New South Wales.

Gentlemen,—I beg to acknowledge the receipt of your letter of the 4th instant, conveying the resolution carried by the members of your Society at the Annual General Meeting in respect to the late CHARLES MOORE, and I now desire to return thanks on behalf of myself and the other relatives for the kind sympathy expressed by the members, and for their eulogistic references to the deceased's past connection with your Society.

I remain, gentlemen, yours respectfully,

MARGARETTA VAN HEUCKELUM.

The following report was presented by Professor LIVERSIDGE at the Annual General Meeting, 3rd May, 1905:—

INTERNATIONAL CATALOGUE OF SCIENTIFIC LITERATURE.

In 1903 I was appointed by the Council of this Society acting as the Regional Bureau for New South Wales, to represent this State at the Council Meetings held in London in May last. I duly attended the meetings and now have the honour to make the following report. The Royal Society of London commenced the work by compiling Catalogues of Scientific Papers (printed between 1800 and 1883) in twelve large quarto volumes, the first volume of which was issued in 1867. In it the titles are arranged solely under the authors' names A catalogue of the papers published since, *i.e.*, between 1884 and 1900 is now in hand, and a subject index is also nearly completed.

The possibility of preparing a complete catalogue of current scientific literature was considered by the Royal Society in 1893, but as it was apparent that the work was beyond the resources of the Royal Society, or indeed of any single body, the society sought the opinion of representative foreign bodies and individuals and the replies being favourable, steps were taken to summon an International Conference. This conference, at which I was present as a Delegate, took place in London on July 14th to 17th, 1896, and was attended by delegates appointed by the Governments of Canada, Cape Colony, Denmark, France, Greece, Hungary, India, Italy, Japan, Mexico, Natal, the Netherlands, New South Wales, New Zealand, Norway, Queensland, Sweden, Switzerland, the United Kingdom, and the United States. It was then unanimously resolved to compile and publish a complete catalogue of current scientific literature, arranged both according to subject matter and authors' names. The Royal Society was requested to appoint a committee to further consider the system of classification to be adopted and other matters, and it was decided to establish the Central Bureau in London.

At the second International Conference held in London on October 11th to 13th, 1898, several questions were settled and a provisional International Committee appointed which afterwards met in London on August 1st to 5th, 1899, when the work was still further expedited and the Royal Society requested to organise the Central Bureau and make all necessary arrangements so that the preparation of the catalogue might be commenced in 1901.

A third International Conference was held in London on June 12th and 13th, 1900, at which all financial and other difficulties were removed by the Royal Society agreeing to act as publishers and to advance the funds necessary to start the enterprise. The supreme control over the catalogue is now vested in an International Convention which is to meet in London in 1905, in 1910, and every tenth year afterwards, to reconsider, and if necessary, to revise the regulations for carrying out the work of the catalogue. In the interval between two successive meetings of the Convention

the administration of the catalogue is carried out by the International Council, the members of which are appointed by the Regional Bureaus.

The total expenditure from July 1st, 1900 to February 29th 1904, has been £10,153, and the total amount received from subscribing bodies was £6,755; eventually the publication will pay its way, but it may be some time before the debt to the Royal Society will be extinguished. The financial support given by the different countries is shown in the following list. New Zealand has now become a contracting body:—Austria £165, Canada £119, Cape Colony £109, Denmark £102, Egypt £17, Finland £45, France £754, Germany £901, Greece £34, Holland £133, Hungary £68, India and Ceylon £471, Italy £459, Japan £255, Mexico £85, New South Wales £34, New Zealand £17, Norway £85, Nova Scotia £17, Orange River Colony £17, Poland £17, Portugal £17, Queensland £34, Russia £512, South Australia £34, Sweden £85, Switzerland £119, United Kingdom £765, United States £1,251, Victoria £17, Western Australia £17—Total £6,755.

It has been suggested that special efforts should be made by the Regional Bureaus to bring the catalogue under the notice of scientific workers, and to secure an increase in the number of subscribers The whole of the first and second issues of the International Catalogue of Scientific Literature have been published with the exception of the volumes on botany and zoology; the third annual issue is in preparation and several of them are already in the press. The number of entries in the author-catalogue of the first annual issue was 43,447, and the total number of entries in that issue was 149,768. The numbers of books and papers indexed in the volumes of the second annual issue are as follows:—A. Mathematics 1,843; B. Mechanics 841; C. Physics 2,433; D. Chemistry 5,632; E. Astronomy 1,223; F. Meteorology 1,988; G. Mineralogy 1,307; H. Geology 1,702; J. Geography 2,022: K. Palæontology 638; L. General Biology, 689; M. Botany 6,339; N. Zoology 7,131; O. Anatomy 1,424; P. Anthropology 1,861; Q. Physiology 9,671; R. Bacteriology 3,132. The

total number of entries in the author catalogue of the second annual issue is therefore 49,876, an increase of 6,429, or about 15% more than the number in the first annual issue. The total number of pages in the first annual issue is 8,387.

The following table shows the number of slips *received* and the instalments in which they were supplied to the Central Bureau:—

Germany	146,552	slips in	59	instalments
France	46,702	„	38	„
United Kingdom	43,484	„	166	„
United States	37,688	„	68	„
Russia	21,071	„	5	„
Italy	13,473	„	25	„
Holland	6,657	„	17	„
Austria	6,379	„	2	„
Poland	3,492	„	8	„
India and Ceylon	2,231	„	39	„
Japan	2,208	„	10	„
Switzerland	1,932	„	7	„
Hungary	1,745	„	4	„
Denmark	1,722	„	17	„
Sweden	1,457	„	4	„
Victoria	1,415	„	3	„
Norway	1,303	„	12	„
New South Wales	1,016	„	5	„
Finland	707	„	8	„
South Africa	645	„	4	„
Belgium	584	„	2	„
Canada	537	„	11	„
New Zealand	327	„	3	„
South Australia	130	„	4	„
Western Australia ...	16	„	1	„
	343,503	„	522	instalments

It was originally intended that the catalogue should not only contain the titles of papers, but that their subject matter should be fully indexed also; financial considerations have, however, led to the number of subject-entries being at present limited in number. The title slips received at the Central Bureau very often showed that the papers were insufficiently indexed, especially in the lists of new species in botany and zoology; also chemistry; in many cases the Central Bureau has made good these deficiencies. The

Executive Committee urge that efforts should be made in all countries to supply fuller information as to the contents of papers; if this were done the catalogue would be much more complete and the cost would be much decreased, and all Journals are urged to index each paper and attach the registration numbers at the time of publication.

At the meeting of the International Council held at the Royal Society's House, London, May 23rd and 24th, 1904, it was resolved in consequence of the success achieved by the International Catalogue of Scientific Literature, and of its great importance to scientific workers, to recommend that its publication be continued The agreement with the contracting countries was made in the first instance for five years only, in case the publication of the catalogue should fail financially or in other ways. It was also decided to spend £100 in making the catalogue known, and to take steps to invite the cooperation of other countries not yet represented on the council, *e.g.* Spain, the Balkan States, South American Republics, etc.

The proposal to publish additional volumes upon, *a.* Medicine and Surgery; *b.* Agriculture, Horticulture and Forestry; *c.* Technology (various branches) was discussed, and it was decided that the executive committee should take the suggestion into fuller consideration and bring it under the notice of the International Convention in July 1905. It was also resolved that all alterations in the schedules should be collected and edited by the Central Bureau prior to submission to the Regional Bureaus for their opinions, and that the schemes should be edited by a special committee before being submitted to the International Convention.

(Signed) A. LIVERSIDGE.

A circular letter from Heidelberg was read respecting the erection of a monument in that city in memory of ROBERT BUNSEN, and as an expression of the debt of gratitude which the world owes him for his great contributions to science and technology. Professor BUNSEN was an Honorary Member of the Royal Society of New South

Wales from 1895. Contributions will be received by the Hon. Secretaries for transmission to Heidelberg, or they may be sent direct to the Hon. Treasurer Herr A. RODRIAN, Stadtrat (in Firma C. Desaga) Heidelberg, Germany.

THE FOLLOWING PAPER WAS READ:

"On the so-called Gold Coated Teeth in Sheep." By A. LIVERSIDGE, LL.D., F.R.S., Professor of Chemistry, University of Sydney.

Paragraphs have appeared recently in some of the London and Sydney newspapers, stating that gold coated teeth have been found in Australian sheep. I have recently received the lower half of a sheep's jaw bone from Dubbo, the teeth of which are more or less completely incrusted with a yellow metallic substance, but more like iron pyrites (marcassite) or brass than gold. The deposit is about $\frac{1}{32}$ of an inch, or less than 1 mm. in thickness. Under a half inch objective it is seen to be made up of thin translucent layers but there is no recognisable organic structure. The metallic lustre is due to the way in which the light is reflected from the surface of the superimposed films. The scale partly dissolves in dilute acids. The residue consists of filmy organic matter, still possessing a metallic sheen although white in colour instead of yellow. The chemical examination shows that the incrustation on the teeth is merely a tartar-like deposit made up principally of calcium phosphate and organic matter.

Note.—Professor LIVERSIDGE also showed a calculus of a similar metallic looking character from a sheep's stomach, deposited in distinct layers round a piece of twig, but of rather a darker bronze tint than the substance on the teeth —this specimen belongs to the Sydney Technological Museum, and was kindly lent for exhibition by the Curator, Mr. R. T. BAKER.

EXHIBITS.

1. Mr. J. H. MAIDEN exhibited and described some of the identical plants gathered by Banks and Solander on Captain Cook's first expedition in 1770.

2. Mr. HENRY DEANE exhibited photograph of a painting of Sydney, date about 1810. Explanatory remarks concerning it were made by Mr. J. J. FLETCHER and Mr. DEANE; the latter kindly presented the photo to the Society. Mr. DEANE also showed a portrait of the Viscount Sydney after whom this city was named.

3. Mr. HENRY G. SMITH exhibited specimens of alcohol from Germany, which he described at some length. Remarks were made by Mr. G. H. KNIBBS, Prof. LIVERSIDGE, Mr. R. T. BAKER, Mr. S. H. BARRACLOUGH, and Dr. G. HARKER.

4. Mr. D. CARMENT exhibited and explained the working of a new calculating machine.

5. Dr. WALTER SPENCER exhibited specimens of woven Piña fibre, collection of Chinese gold coins, objects which formed the sole export of the Loo-Choo Islands 30 years ago, &c.

ABSTRACT OF PROCEEDINGS, JULY 5, 1905.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, July 1st, 1905.

H. A. LENEHAN, F.R.A.S., President, in the Chair.

Twenty members were present.

The minutes of the preceding meeting were read and confirmed.

The certificates of six candidates were read for the third time, of four for the second time, and of one for the first time.

The following gentlemen were duly elected ordinary members of the Society:—

BOARD PETER, M.A. Syd.; Under Secretary and Director of Education, Department of Public Instruction, Sydney.

FOY, MARK; Merchant, "Eumemering," Bellevue Hill, Rose Bay.

HOOPER, GEORGE; Registrar, Sydney Technical College, p.r. 'Branksome,' Henson-street, Summer Hill.

JENSEN, HAROLD INGEMANN; Macleay Fellow of the Linnean Society of N.S. Wales, 31 Arcadia Road, Glebe Point.

MOORS, ELPHINSTONE MACM., M.A. Melb., F.I.A., Lond.; 'Kallista,' Raglan Street, Mosman.

TURNER, JOHN WILLIAM; Assistant Under Secretary, Department of Public Instruction; Department of Public Instruction, Sydney.

Mr. W. A. DIXON, by permission of the President, made the following remarks:—He had often found that young men were quite willing to work out any investigation, but that they were not aware of any subject which would repay them; he, therefore, desired to suggest one in which he had found no information. He thought it deserved investigation, but had no time himself to attempt it. He had in his dining-room a Fletcher's gas fire, an upright fire-clay block, with tufts of asbestos heated to radiation of heat point by a Bunsen flame. Some years ago, sitting in front of this it occurred to him that it would be an improvement to convert the colorless flame to a colored one, and therefore twisted some wires into a rope and saturated this with brine to obtain a sodium flame. Next night the

fire having got hot, he introduced the saturated wire at the base of the flames, and immediately found a great reduction in the radiation, so that he felt quite cool. Removal of the wires and re-insertion several times always produced the same effect.

The subject he had to suggest was, therefore, "The Radiation from Coloured Flames." To this might very well be added the absorption of radiant heat by coloured glass, which varies much. In this part it would be necessary to use coloured glass of standard light penetration, such as is used in Lovibond's Tintometer.

Remarks were made by Dr. F. H. QUAIFE and Mr. G. H. KNIBBS.

The President made the following announcements:—

1. The death of the Hon. Sir AUGUSTUS CHARLES GREGORY K.C.M.G., M.L.C., F.R.G.S., Brisbane, who was elected an Honorary Member of the Society in 1875, and awarded the Clarke Memorial Medal in 1896. It was resolved that a letter of condolence be forwarded to the relatives of the deceased.

2. That the Officers and Committee of the Engineering Section had been elected for the present Session:—

Sectional Committees—Session 1905.

Section K. Engineering.

Chairman—JOSEPH DAVIS, M. Inst. C.E.

Hon. Secretary—J. HAYDON CARDEW, Assoc. M. Inst. C.E.

Committee—T. H. HOUGHTON, M. Inst. C.E., M. I. Mech. E., G. R. Cowdery, Assoc. M. Inst. C.E., T. W. Keele, M. Inst. C.E., W. E. Cook, M. Inst. C.E., NORMAN SELFE, M. Inst. C.E., M. I. Mech. E., J. I. HAYCROFT, Assoc. M. Inst. C.E., J. N. C. MACTAGGART, B.E., R. T. MCKAY, C.E., F. M. GUMMOW, M.C.E.

Past Chairmen—J. M. SMAIL, M. Inst. C.E., H. G. MCKINNEY, M. E, M. Inst. C.E., S. H. BARRACLOUGH, M.M.E., Assoc. M. Inst. C.E.

Thirty-six volumes, 259 parts, 9 reports, 127 pamphlets, and 1 photograph, total 432, received as donations, were laid upon the table and acknowledged.

THE FOLLOWING PAPER WAS READ:

1. "Observations on the Illustrations of the Banks and Solander Plants," by J. H. MAIDEN, Government Botanist and Director of the Botanic Gardens, Sydney.

The issue of the third and final volume and plates, from the coppers engraved in the 18th century, from drawings by Nodder, Cheveley, and the two Millers, prepared under the direction of Banks, and depicting over 400 plants collected by him in 1770, during Cook's first voyage, is, to Australians at least, an important historical event, which assuredly demands the most marked emphasis that Australians can give it. The present work has been written by Mr. James Britten of the British Museum, with the authority of the trustees of that institution. Many of Banks' plants depicted were presented by the trustees to the National Herbarium, Sydney. The scope of this work is explained, and the proposed changes in nomenclature are indicated and compared with the names in the "Flora Australiensis." This handsome publication, apart from its historical value, is a notable addition to existing iconographies of Australian plants.

Remarks were made by Mr. W. J. CLUNIES ROSS, Mr. R. T. BAKER, Mr. W. M. HAMLET, and the Author.

EXHIBITS:

1. Professor LIVERSIDGE, M.A., F.R.S., exhibited "Fused Quartz," also special apparatus.

2. Mr. T. H. HOUGHTON, M. Inst. C.E., exhibited Sections and illustrations of the Locking Bar Pipes as used for the Coolgardie Water Supply, also specimen of the Universal Joint.

3. Professor T. W. E. DAVID, B.A., F.G.S., F.R.S., exhibited a collection of Thinolites. Some remarks were made by Mr. CHARLES ANDERSON.

ABSTRACT OF PROCEEDINGS, AUGUST 2, 1905.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, August 2nd, 1905.

H. A. LENEHAN, F.R.A.S., President, in the Chair.

Twenty-five members were present.

The minutes of the preceding meeting were read and confirmed.

Mr. GEORGE HOOPER enrolled his name and was introduced.

Messrs. W. J. CLUNIES ROSS and F. B. GUTHRIE were appointed Scrutineers, and Mr. W. M. HAMLET deputed to preside at the Ballot Box.

The certificates of four candidates were read for the third time, of one for the second time, and of one for the first time.

The following gentlemen were duly elected ordinary members of the Society:—

Blakemore, George Henry, General Manager for the Great Cobar Mining Syndicate, Lithgow.

Hoskins, George I., Engineer, Burwood Road, Burwood.

Miller, James Edward, Cobar.

Scott, Ernest Kilburn, Electrical Engineer, The University, Sydney.

The Chairman announced (1) that the Society's Journal, Vol. XXXVIII., for 1904 was in the binder's hands and would be distributed as speedily as possible. (2) That the Second Popular Science Lecture 1905, on "The Monotremes and the Origin of Mammals," (illustrated by lantern slides) by J. P. HILL, D.Sc., F.L.S., Lecturer in Embryology etc., Sydney University, would be delivered on Friday, 18th August at 8 p.m.

Forty-four volumes, 241 parts, 7 reports and 15 pamphlets, total 307, received as donations since the last meeting were laid upon the table and acknowledged.

The following letter was read :—

Rosalie, 23rd July, 1905.

To the Hon. Secretaries, Royal Society of N.S. Wales, Sydney.

Dear Sirs,—I have the honour to acknowledge the receipt of your letter of 15th instant, conveying to us the kind expressions of sympathy expressed by the Royal Society of New South Wales, Sydney. I, on behalf of myself and brother, have to request that you will kindly thank them on our behalf for their sympathy with us in our late bereavement.

Yours faithfully,

F. W. Gregory.

THE FOLLOWING PAPER WAS READ:

"The refractive indices, with other data, of the oils of 118 species of Eucalyptus," by Henry G. Smith, F.C.S., Assistant Curator, Technological Museum, Sydney.

In this paper the author records the refractive index, the specific gravity, the specific refractive energy and the solubility in alcohol of the oil of each species. The material was distilled at the Museum, and most of it had been prepared for the work "Research on the Eucalypts and their Essential Oils," by Mr. R. T. Baker and himself, so that it was of undoubted origin. The oils of those species which have been obtained since that work was published are also included. By working upon the oils of such a large number of species it was possible to arrange the results in some order. The specific refractive energy results cannot be used to any great extent for the purpose of classification, but if the refractive index be multiplied by 10 times the solubility in 70% alcohol, (sp. gr. 0·8722 at 15·5° C.) a very good arrangement of the eucalyptol oils can be made. Those oils which contained eucalyptol in excess had, as a rule, the least refractive index, and were the most soluble in alcohol. As the pinene increased in amount the solubility diminished and although the refractive index remained

much the same, yet, the resulting figures increased considerably. The solubilities were taken in tenths, and the temperature for all the determinations was 16° C. The oils of the 51 species in the eucalyptol group had refractive indices ranging from 1·4686 to 1·4774 and the solubility was from 1·05 to 8 volumes 70% alcohol, down to No. 45, the remaining six being insoluble in 10 volumes. The specific gravities of the oils of this group were mostly above 0·91. The 7 pinene oils in which phellandrene was absent had refractive indices ranging from 1·4741 to 1·4788, and none were soluble in less than 7 volumes 80% alcohol. The pinene oils (14 species) in which the sesquiterpene was pronounced, and phellandrene absent, had refractive indices ranging from 1·4801 to 1·4948, while the oils which contained the aldehyde aromadendral in some quantity, and in which phellandrene was absent (9 species) had refractive indices from 1·4828 to 1·4946. The refractive indices of the phellandrene oils which contained piperitone (11 species) ranged from 1·4828 to 1·4945. The 22 phellandrene oils in which the sesquiterpene was a pronounced constituent had refractive indices ranging from 1·4801 to 1·5065. The perfumery oils as *E. citriodora*, *E. Macarthuri* and *E. Staigeriana* were not classified.

Remarks were made by Mr. W. A. Dixon, Mr. W. M. Hamlet, Dr. George Harker and Mr. G. H. Knibbs. The author replied.

Mr. Lenehan exhibited a chart illustrating Trans Pacific Longitude, and read a letter from Dr. Klotz in connection therewith.

Some remarks were made by Mr. Knibbs and the President.

ABSTRACT OF PROCEEDINGS, SEPTEMBER 6, 1905.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, September 6th, 1905.

H. A. LENEHAN, F.R.A.S., President, in the Chair.

Twenty-seven members were present.

The minutes of the preceding meeting were read and confirmed.

Messrs. R. P. SELLORS and J. BROOKS were appointed Scrutineers, and Mr. W. M. HAMLET deputed to preside at the Ballot Box.

The certificate of one candidate was read for the third time, of one for the second time, and of three for the first time.

The following gentleman was duly elected an ordinary member of the Society. viz.:—

Taylor, John M., M.A., LL.B. (Syd.), North Sydney.

The Chairman announced that bound copies of the Society's Journal, Vol. XXXVIII., for 1904 could be had on application to the Assistant Secretary.

Thirty-two volumes, 243 parts, 20 reports, and 2 pamphlets, total 297, received as donations since the last meeting, were laid upon the table and acknowledged.

THE FOLLOWING PAPERS WERE READ:

1. "Reinforced Concrete," Paper III., by Professor W. H. WARREN, Wh. Sc., M. Inst. C E., M. Am Soc. C.E., Challis Professor of Engineering, University of Sydney.

The following matters were dealt with:—

a. The adhesion of cement mortar and concrete to steel.

b. The experimental determination of the neutral axis in a plain concrete, and also in a reinforced concrete beam, and the curves of strain for loads increasing from zero to

the load producing fracture; the determination of the true form of the stress curve from the actual strain curve in a plain and in a reinforced concrete beam.

c. The safe working stresses and the fundamental equations recommended for the design of reinforced concrete structure.

d. The adhesion of cement mortar and concrete to the steel reinforcement was determined by pulling out specially prepared bars of Bessemer steel from prisms 12 inches long × 4 inches × 4 inches cross section, by means of a testing machine.

i. With steel bars having the natural skin on, after 45 days hardened in air	198 lb per sq. inch
ii. With the skin removed and the bars polished, after 45 days hardened in air	125 ,, ,, ,,
iii. With the skin removed as in ii., but hardened in water, after 45 days	185 ,, ,, ,,

b. The experimental determination of the neutral axis in a plain and in a reinforced concrete beam, also the curves of strain for loads increasing from zero to that necessary to produce fracture, was made in a special form of Buckton testing machine, with two hydraulic presses for applying the loads at the ends of the beams tested. Ten beams 72 inches long were tested on supports 40 inches centre to centre, with two overhanging portions each 16 inches long. The apparatus for measuring the lengthening and shortening of the beam between the supports over a length of 40 inches, consisted of eight Martens' mirror extensometers, with a corresponding number of scales and telescopes arranged at different positions in the depth of the beam. The extreme fibre strains were determined by

were described:—(1) Hypersthene Gabbro; (2) Augite Peridotite; (3) Enstatite Peridotite, containing Picotite; (4) Pyroxenite. The dyke rock was shown to be a monchiquite. The occurrence of these inclusions (xenoliths) taken in conjunction with those occurring at Bulli, Dundas and various localities in the Sydney District, points to the occurence of large areas of basic and ultrabasic plutonic rocks at some distance below the surface in this part of New South Wales.

EXHIBITS.

Professor WARREN read some notes on hardness of different metals, and exhibited a Sclerometer for testing same.

Mr. LENEHAN exhibited and explained a chart showing drift of the s.s. "Pilbarra," after losing her propeller blades.

ABSTRACT OF PROCEEDINGS, OCTOBER 4, 1905.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, October 4th, 1905.

H. A. LENEHAN, F.R.A.S., President, in the Chair.

Thirty-six members and three visitors were present.

The minutes of the preceding meeting were read and confirmed.

Messrs. F. B. GUTHRIE and R. T. BAKER were appointed Scrutineers, and Prof. LIVERSIDGE deputed to preside at the Ballot Box.

The certificate of one candidate was read for the third time, of three for the second time, and of one for the first time.

The following gentleman was duly elected an ordinary member of the Society, viz:—

SIMPSON. D. C., M. Inst. C.E.; North Sydney.

Three volumes, 118 parts, 4 reports and 2 pamphlets, total 127, received as donations since the last meeting, were laid upon the table and acknowledged.

The following note was read and explanatory remarks made upon the several exhibits shown:—

"Note on some simple Models for use in the Teaching of Elementary Crystallography," by W. G. WOOLNOUGH, D.Sc. [Communicated by Prof. T. W. E. DAVID, B.A., F.R.S.]

Dr. WOOLNOUGH exhibited models to illustrate the connection between the number of faces in a crystal "form" and the elements of symmetry of the group to which the crystal belongs. He explained briefly that all crystals are symmetrical bodies, the symmetry being due to a regular repetition of similar faces with respect to planes, axes, and a centre of symmetry. Planes of symmetry divide crystals into parts which bear the same relation to one another as an object and its reflection in a mirror. With respect to axes of symmetry, the repetition of faces is rotational in character. Planes of symmetry are therefore represented in the models by mirrors suitably arranged, and crystal faces by triangles of cardboard. The mirrors are so fixed that the multiple reflection of the card reproduces the shape of the most general form possible in the crystal group. In this way it is very strikingly shown that in the normal groups of the cubic, tetragonal, hexagonal, and rhombic systems are closed forms of 48, 16, 24

and 8 faces respectively. The model for the normal group of the monoclinic system consists of a mirror pierced by an axis capable of rotation, the cards representing faces are fixed in such a way as to show, by rotation of the axis through 180°, that the general form consists of four faces only, and is open. In the normal group of the triclinic system, where there is only a centre of symmetry, this is represented by a spherical cork, on opposite sides of which two equal and similar cards are carried showing that every form in this group is open and consists of two faces only.

Remarks were made by Prof. DAVID, Mr. S. H. BARRACLOUGH, and Mr. G. H. KNIBBS.

EXHIBITS.

Prof. LIVERSIDGE exhibited specimens of metallic calcium and described its preparation and physical properties. Some remarks were made by Mr. GUTHRIE.

Mr. J. H. MAIDEN exhibited and commented upon the following :—

1. The Thready-barked She Oak from Northern N.S.W. (*Casuarina inophloia*). Remarkable for the texture of its bark, its coarse medullary rays, and the uninflammable character of its wood.

2. Fresh male amenta of *Araucaria Rulei*, an interesting New Caledonian species which rarely produces male flowers in Sydney.

3. *Selaginella lepidophylla*, an American plant (Mexico to Peru, etc.) which, artificially scented with oil of cinnamon is at present being sold in Australia as the true "Rose of Jericho," which is a Crucifer from Palestine.

Some remarks were made by Mr. R. T. BAKER.

Mr. HENRY DEANE, M.A., M. Inst. C.E., exhibited a series of photographs of the Frank, (Alberta Territory, Canada)

Rock Slide of 29 April, 1903. See Report, Department of the Interior, Dominion of Canada. Extract from Part viii., Annual Report 1903, Ottawa, 1904 :—

1. Turtle Mountain, part of easterly range of Rocky Mountains.

2. Summit 3,000 feet above valley of Old Man River. Upper Palæozoic Limestone, above Cretaceous shales and sandstones below.

3. Slipping mass, one-half mile square, and probably 400 to 500 feet thick. It crossed the valley, rising to a height of 400 feet on the other side. Distance from summit to end of slide 2½ miles. Area covered by débris 1·03 sq. m. Number of lives lost about 70.

Remarks were made by Prof. DAVID, Dr. WALTER SPENCER and Mr. G. H. HALLIGAN.

ABSTRACT OF PROCEEDINGS, NOVEMBER 1, 1905.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, November 1st, 1905.

H. A. LENEHAN, F.R.A.S., President, in the Chair.

Twenty-five members and two visitors were present.

The minutes of the preceding meeting were read and confirmed.

His Honor Judge DOCKER and Mr. ALG. PEAKE were appointed Scrutineers, and Mr. HAMLET deputed to preside at the Ballot Box.

The certificates of three candidates were read for the third time, of one for the second time, and of five for the first time.

The following gentlemen were duly elected ordinary members of the Society, viz.:—

BIGNOLD, HUGH BARON, Barrister-at-Law; Chambers, Wentworth Court, Elizabeth-street.

DAMPNEY, GERALD F., Fellow of the Society of Chemical Industry; "Doonbah," Hunter's Hill.

HYDE, ELLIS, Analyst; 27 York-street.

Thirty-three volumes, 191 parts, 24 reports, 7 pamphlets and 8 maps, total 263, received as donations since the last meeting, were laid upon the table and acknowledged.

Prof. LIVERSIDGE gave notice of motion that Rule XXVIII. be altered to read as follows:—

"Meetings of the Council of Management may take place on the last Wednesday in every month or on such other days as the Council may determine."

THE FOLLOWING PAPER WAS READ:

"Provisional Determination of Astronomical Refraction, from observations made with the Meridian Circle instrument of the Sydney Observatory," by C. J. MERFIELD, F.R.A.S., Mitglieder der Astronomischen Gesellschaft.

This paper gives the results of an investigation into astronomical refraction, deduced from some five hundred and fifty observations of forty fundamental stars taken with the meridian circle of the Sydney Observatory during the month of July 1905. The author fully explains the methods adopted in dealing with the observed data, showing its advantages and otherwise. Two examples of the adopted forms used in the reduction are given, by which the simplicity of the method is well illustrated. After completing the discussion of the data, the results are formed

into normals with the zenith distance as argument. An examination of these results clearly indicates that the so called constant of refraction needs, not only a correction, but one for every zenith distance. It may be remarked that similar conclusions have been obtained by recent investigators in this connection. From the results of this work the author arrives at a value of the constant

$$a = 60''\cdot283$$

$$\text{for } B = 760 \text{ mm. at } 0\ (C) \text{ and } t = 0\ (C)$$

It would appear from this investigation, however, that the formula from which the refractions are computed requires modification. The formula may be retained unaltered and the desired result obtained by correcting the value of Log a of the tables in a manner shewn in the paper. Thus we have $\quad \text{Log} \vartriangle a = +\ 0\cdot000122\ [52^\circ\ 30'\ 33'' - z]$
in which z equals the zenith distance in arc.

The conclusions arrived at by the author are as follows: That if observations of zenith distance of celestial objects are taken between limits of time separated by some hours, then greater accuracy in the reductions, to obtain correct positions, can be obtained by taking fully into consideration the fluctuations of the height of the barometer and especially the variation of the temperature, indicated by the readings of the thermometer, when computing the refractions for a series of observations extending over a period of several hours duration. Adopting a state of the atmosphere for a mean of the times of observation does not seem sufficient. Further, the refraction table, (Bessel), in use at the Sydney observatory would represent the observed refractions much better, if a correction be applied for the difference in the force of gravity at Greenwich and Sydney. This correction is represented by a very simple equation which is a function of the latitudes of the two places. The author also considers that the refractions

computed from the Pulkowa tables, after applying the gravity correction, would represent the observed values better than those of Bessel.

Remarks were made by Mr. KNIBBS and the President.

EXHIBITS.

Professor LIVERSIDGE exhibited plants of British Woad, *(Isatis tinctoria)* in flower and gave an account of woad and its uses, of which the following is an abstract :—*Isatis tinctoria* is a biennial herbaceous crucifer. The flowers are small, yellow, and borne in spreading clusters, or panicles. The leaves are large, smooth, and lanceolate or spathulate. The seeds from which the plants exhibited were grown, were sown in his garden in July or August last, and the plants are about 3 feet 6 inches high, and although biennial, have been in flower for about a fortnight or three weeks. The seeds were obtained from Mr. Howard's Woad mill at Parson Drove about 6 miles from Wisbech, on August 20th, 1904, when Professor Liversidge was one of a party from the British Association meeting at Cambridge, visiting the woad mill and farm. The party were told that there was only one other woad farm left, viz: near Holbeach in Lincolnshire, and that one of the two (Parson Drove ?) was about to be relinquished and the land used for other purposes.

Woad is a native of South Europe, and before the introduction of indigo was very largely used as a blue dye and was extensively cultivated in various parts of Europe. According to Pliny, the ancient Britons used it for staining their skin blue. In England it was formerly cultivated in several places, but it is now only grown in two places, in the fen lands of Lincolnshire, and Cambridgeshire. It requires very good soil and the land fetches £10 an acre rent, and from £150 to £200 freehold. The seeds are sown in March or April, and the first crop of leaves is gathered

from near base of the plant in June, one or two more gatherings may be made at intervals of a month or six weeks. The freshly gathered leaves are at once ground to a pulp in roller mills (worked by horses) very similar to a clay mill, in a circular thatched shed, the rollers are slightly conical hollow wooden drums, fitted with 25 or 30 longitudinal iron bars to serve as the crushing edges, the pulp is removed and allowed to drain; when sufficiently dry, it is worked up into balls of about 4 inches to 6 inches diameter, by hand on a tray ('balling horse'). The hands of the women who worked the woad into balls were slightly stained blue. The balls are placed on gratings arranged in tiers in sheds ('ranges,') with open sides so as to allow free circulation of air. When the whole of the crop has been treated in this way the balls are ground to a coarse powder in the roller mill, which is spread over the floor of the 'couching house' to a depth of two or three feet, and worked up into a paste by frequently sprinkling with water and turning over with spades. This goes on for several weeks. During this process fermentation is set up; at first there is a considerable rise in temperature, the mass steams and an offensive smell is given off. The operation requires much care and some skill; if carried out too slowly the product is 'heavy' or sodden, and if too quickly 'foxy.' When the fermentation is over and the pasty mass has cooled down it is packed in casks for market. Nine parts of the leaves yield about 1 part of prepared woad and this may contain 2% of indigotin, but some samples contain none at all. A few years ago it fetched £25 a ton, it is now worth only £9.

It is not now used for the sake of the dye, but is employed to start fermentation in the indigo vat (or woad vat) used by the Yorkshire woollen dyer, and its use will, now that artificial indigo is coming into use, soon be given up altogether. Imitation woad is made from rhubarb, cabbage

and other leaves, but they are inferior in starting fermentation. Indican, the glucoside yielding indigo blue can be extracted from the dried woad leaves by ether, on washing this with water and evaporating the water solution the indican is left as a pale brown syrup, soluble in spirit, ether, etc. Indican is very unstable, boiling or long heating its solution decomposes it and it yields indiglucin but no indigotin, *i.e.*, indigo blue when treated with acids. To illustrate the process of dyeing with woad; digest half a pound of woad with a gallon of water, in a closed vessel, at 100° F., for 12 or more hours; then stir in about $\frac{1}{4}$ oz. of lime. The indican ($C_{26}H_{31}NO_{17}$) undergoes hydrolysis and indigo-white is formed. If now a skein of white wool be placed in the liquid for an hour or so, on taking it out and exposing it to the air it will acquire a pale blue colour; the soluble indigo-white hydrindigotin ($C_{16}H_{12}N_2O_2$) or reduced indigo is oxidised by the air to insoluble indigo-blue or indigotin ($C_{16}H_{10}N_2O_2$).

An interesting account of the preparation and use of woad from the pen of Dr. C. B. Plowright, will be found in "Nature" of 1st February, 1900.

Remarks were made by Mr. W. A. Dixon and Mr. Maiden.

The experiment with Dr. Quaife's Lantern Electric Lamp was unavoidably postponed.

Mr. S. Henry Barraclough exhibited the Tantalum Lamp with stereoscopic photographs of Clarke Maxwell's Thermodynamic surface.

Mr. H. A. Lenehan, showed various diagrams of modern astronomical instruments for eclipse observations.

ABSTRACT OF PROCEEDINGS, DECEMBER 6, 1905.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, December 6th, 1905.

H. A. LENEHAN, F.R.A.S., President, in the Chair.

Thirty members and one visitor were present.

The minutes of the preceding meeting were read and confirmed.

Mr. T. F. FURBER and Dr. F. H. QUAIFE were appointed Scrutineers, and Mr. D. CARMENT deputed to preside at the Ballot Box.

The certificate of one candidate was read for the third time, of five for the second time, and of one for the first time.

The following gentleman was duly elected an ordinary member of the Society. viz.:—

SCHEIDEL, AUGUST, Ph D., Union Club.

Mr. DAVID FELL, C.A.A., M.L.A., and Mr. FERDINAND BENDER, were appointed Honorary Auditors for the current year.

The President announced (1) that the Council recommended the election of the following gentlemen as Honorary Members of the Society:—

EMIL FISCHER, Professor of Chemistry, University, Berlin.

STANISLAO CANNIZZARO, Professor of Chemistry, Reale Università, Rome.

DANIEL OLIVER, LL.D., F.R.S., Emeritus Professor of Botany, University College, London.

The election was carried unanimously.

(2) The death of Captain F. W. HUTTON, F.R.S., Curator, Canterbury Museum, Christchurch, New Zealand, elected Honorary Member 1888, Clarke Medallist 1891.

Professor LIVERSIDGE submitted an obituary notice of the deceased gentleman, and afterwards moved the following resolution, which was seconded by His Honor JUDGE DOCKER and carried unanimously:—

(*a*) "The members of the Royal Society of New South Wales learn with the deepest regret of the death of Captain HUTTON, F.R.S., one of its Honorary Members, and they hereby place on record their high appreciation of Captain HUTTON's great and life long services for the advancement of science."

(*b*) "That the above resolution be forwarded to the late Captain HUTTON's family with an expression of this Society's deep sympathy with them in their bereavement."

Twenty-two volumes, 131 parts, 56 reports, 12 pamphlets and 8 maps, total 229, received as donations since the last meeting, were laid upon the table and acknowledged.

THE FOLLOWING PAPERS WERE READ:

1. "A method of separating the clay and sand in clay soils and those rich in organic matter," by L. COHEN, Chemical Laboratory, Department of Agriculture. (Communicated by F. B. GUTHRIE, F.I.C., F.C.S.)

The methods usually adopted for separating sand and clay in the analyses of soils involve boiling with water, with dilute alkali, pestling etc., before elutriation. These processes have with certain classes of soils produced unsatisfactory results. The deficiencies of these methods are more apparent in humus and clay soils, owing to the cohesive power of the organic matter present, the vegetable fibre (cellulose) exerting a binding effect on clay particles

and causing them to behave in the elutriator as if they were sand grains. In order to eliminate the fibre the author uses a solution of zinc chloride in hydrochloric acid (40% HCl) with gratifying results. A weighed quantity, 30 gm. of the soil is passed through a sieve containing 50 meshes to the inch, and the resulting fine soil boiled in about 100 cc. of the above solution for half an hour. The mass is then cooled, diluted, washed out into the elutriating vessel and the water allowed to flow through. When the overflow water is quite clear, the residue is washed out, dried on the water bath and weighed as sand. A peaty oil containing 22·7% of organic matter yielded 57% of sand by boiling with water alone as compared with 6·17% by the zinc chloride process. Microscopical examination proved the latter to be practically pure sand, while the former contained an overwhelming proportion of clay and vegetable matter. A comparative table is shown giving percentages of sand obtained on treatment with different reagents, from typical soils to which this method more particularly applies.

Remarks were made by Mr. F. B. GUTHRIE, Dr. R. GREIG SMITH, Mr. J. H. MAIDEN, Dr. HARKER, and His Honor Judge DOCKER. Mr. COHEN replied.

2. "Latitude of the Sydney Observatory,"—appendix to a paper on the "Provisional Determination of Astronomical Refraction, from observations made with the Meridian Circle instrument of the Sydney Observatory," by C. J. MERFIELD, F.R.A.S., Mitglieder der Astronomischen Gesellschaft.

This paper contains determination of the latitude of the Sydney Meridian Circle instrument, deduced from zenith pairs used in a previous work, on astronomical refraction, recently communicated. The adopted latitude

$$\phi = -33^\circ\ 51'\ 41{\cdot}1''$$

depended on observations taken, by the Rev. W. SCOTT, M.A.,

[illegible]

[illegible] Australian Tribes [illegible]

[illegible] among the social [illegible] there is none of greater [illegible] than the study of [illegible] He [illegible] expressed his conviction [illegible] "group marriage" [illegible] among the Australian aborigines. He [illegible] the divisions into para- [illegible] had not been deliberately made

with intent to regulate the relations of the sexes, but had been developed in accordance with surrounding circumstances and conditions of life.

Some remarks were made by Mr. R. HELMS.

4\. "On an undescribed species of *Leptospermum* and its Essential Oil," by R. T. BAKER, F.L.S., Curator, and H. G. SMITH, F.C.S., Assistant Curator, Technological Museum, Sydney.

"The Lemon-scented Leptospermum." The species described in this paper occurs in the North Coast District of New South Wales and the Southern Coast District of Queensland. It is a shrub attaining a height from 6 to 12 feet, with erect branches and small, lanceolate, ovate leaves; the flowers occurring in the axils of the leaves on the upper branchlets. The fruits measure about two to three lines in diameter. Its differentiation from described species is based on both morphological and chemical characters, although the former are alone sufficiently marked to warrant its specific rank. It may possibly in the past, have been confused with some of the varieties of *L. flavescens*, but apart from well marked taxonomic characters none of those species give a lemon-scented odour. The leaves and terminal branchlets of this plant yielded 0·227% of an essential oil containing a considerable amount of citral. This appears to be the first time that the oils of the *Leptospermums* have been investigated, and the indications for the previously described species are not commercially promising. However, other species will be worked as opportunity offers. The marked lemon odour given by the leaves when crushed appears to be characteristic of this species, and is an aid in its discrimination. Besides citral (35%) the oil contained dextro-rotatory pinene (25%), an alcohol considered to be geraniol (9·74%), an ester most probably geranyl-acetate (5·35%) and a sesquiterpene.

Citral is the only aldehyde present in the oil, as several ways. The crude oil was soluble in an equ of 80% alcohol, but not in 10 volumes 70% alcohol; specific gravity 0·8095 at 15° C., a refractive inde at 16° C., and a rotation in a 100 mm. tube of 9·2 to the right. The pinene, which on a final recti boiled between 155 – 157° C., had a specific gravity at 15° C., a refractive index 1·4706 at 20°, a r a^{D} + 35·5°, and gave a nitrosochloride melting at 10 purified citral obtained both from the crystalline bisu and from the soluble compound, gave in both sam refractive index 1·4913 at 20° a specific gravity 0·8 the same temperature; it had the odour of citral an gave the naphthocinchoninic acid for that aldehyde. non-aldehydic portion of the oil had a specific gravity 0· at 20°, rotation +13·4° and refractive index 1·4855 at It was esterised in the usual way for the determinati the free alcohol. Limonene could not be detected, were either phellandrene or cineol present. The na proposed for the species is *L. Liversidgei.*

EXHIBITS.

Portion of Lightning Conductor crushed by the discharg exhibited by Mr. D. K. CLARK, with note by Prof. J. A POLLOCK and Mr. S. H. BARRACLOUGH.

Specimens of American timbers by Mr. R. T. BAKER.

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TRANSACTIONS, JOURNALS, REPORTS, &c.

(The Names of the Donors are in *Italics.*)

AACHEN—Meteorologische Observatoriums. Deutsches Meteorologisches Jahrbuch für 1903, Jahrgang IX.. Aachen. *The Director*

ABERDEEN—University. Aberdeen University Studies, Nos. 10, and 11 1904. *The University*

ACIREALE—R. Accademia di Scienze, Lettere ed Arti Degli Zelanti. Rendiconti e Memorie, Serie 3, Vol. III., 1903-4. Memorie della Classe di Lettere. *The Academy*

IDE—Department of Mines. A review of Mining Operations in the State of South Australia during the half year ended December 31, 1904. Record of the Mines of South Australia, Supplementary Issue, 1905. *The Department*

Observatory. Meteorological Observations during the years 1900-1. *The Observatory*

ublic Library, Museum, and Art Gallery. Report of the Board of Governors for 1903-4, 1904-5. *The Director*

Royal Society of South Australia. Transactions and Proceedings, Vol. XXVIII., 1904, *The Society*

NY—University of the State of New York. College Department, Annual Report (6th) 1903. High School Department, Annual Report (10th) 1902, Vols. I., II. Regents' Annual Report (117th) 1903. New York State Library, Annual Report (86th) 1903. New York State Museum, Annual Report (56th) 1902, Vols. I. - IV. Bulletin, Nos. 63, 69 - 82, 1903-5. *The University*

STERDAM—Académie Royale des Sciences. Jaarboek, 1903, 1904 Proceedings of the Section of Sciences, Vol. VI., Parts i., ii., 1903-4; Vol. VII., Parts i., ii., 1904-5. Verhandelingen (Eerste Sectie) Deel VIII., Nos. 6, 7, 1904; Deel IX., No. 1; (Tweede Sectie) Deel X., Nos. 1 - 6, 1903-4; Deel XI., 1905; Deel XII,, Nos. 1, 2, 1905. Verslag van de Gewone Vergaderingen, Deel XII., Gedeelte i., ii., 1903-4; Deel XIII., Gedeelte i., ii., 1904-5. *The Academy*

Société Royale de Zoologie. Bijdragen tot de Dierkunde Aflevering 17, 18, 1893 - 1904. *The Society*

NNAPOLIS, Md.—U.S. Naval Institute. Proceedings, Vol. XXX., No. 4, 1904; Vol. XXXI., Nos. 1, 2, 1905. *The Institute*

UCKLAND—Auckland Institute and Museum. Annual Report for 1904-5. „

BALTIMORE—Johns Hopkins University. American Chemical Journal, Vol. XXXI., Nos. 4 - 6; Vol. XXXII., Nos. 1 - 6, 1904; Vol. XXXIII.. Nos. 1 - 2, 1905. American Journal of Mathematics, Vol. XXVI,, Nos. 1 - 4, 1904; Vol. XXVII., No. 1, 1905. American Journal of Philology, Vol. XXIV., No. 4, 1903; Vol. XXV., Nos. 1 - 3, 1904. Studies in Historical and Political Science, Vol. XXII., Nos. 1 - 12, 1904; Vol. XXIII., Nos. 1, 2, 1905. University Circular, Nos. 2, 3, 5, 7, 8, 1904; No. 1, 1905. *The University*

Maryland Geological Survey. Miocene, (2 vols.) Text and Plates, 1904. *The Survey*

BANGALORE—Mysore Geological Department. Bulletin, No. 3, 1905. Memoirs, Vol, II., 1905. Report of the Chief Inspector of Mines for the year 1903-4. *The Department*

BASLE—Naturforschende Gesellschaft. Verhandlungen, Band XV., Heft 3, 1904; Band XVII., 1904. *The Society*

BERGEN—Bergen Museum. Aarbog, Hefte 3, 1903; Hefte 1, 3, 1904. Aarsberetning, 1903, 1904. An account of the Crustacea of Norway by G. O. Sars, Vol. V., Copepoda Harpacticoida, Parts iii. - viii., 1904-5. Hydrographical and Biological Investigations in Norwegian Fiords by O. Nordgaard and E. Jorgensen, 1905. *The Museum*

Citral is the only aldehyde present in the oil, as proved in several ways. The crude oil was soluble in an equal volume of 80% alcohol, but not in 10 volumes 70% alcohol; it had a specific gravity 0·8095 at 15° C., a refractive index 1·4903 at 16° C., and a rotation in a 100 mm. tube of 9·2 degrees to the right. The pinene, which on a final rectification, boiled between 155 – 157° C., had a specific gravity 0·8601 at 15° C., a refractive index 1·4706 at 20°, a rotation a^D + 35·5°, and gave a nitrosochloride melting at 103°. The purified citral obtained both from the crystalline bisulphite, and from the soluble compound, gave in both samples a refractive index 1·4913 at 20° a specific gravity 0·8937 at the same temperature; it had the odour of citral and also gave the naphthocinchoninic acid for that aldehyde. The non-aldehydic portion of the oil had a specific gravity 0·8866 at 20°, rotation +13·4° and refractive index 1·4855 at 22°. It was esterised in the usual way for the determination of the free alcohol. Limonene could not be detected, nor were either phellandrene or cineol present. The name proposed for the species is *L. Liversidgei.*

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PROCEEDINGS

ENGINEERING SECTION.

:OCEEDINGS OF THE ENGINEERING SECTION.

(IN ABSTRACT.)

The First Meeting of the Section was held 28th June, 1905, at The University.

Mr. S. H. BARRACLOUGH, in the Chair.

The principal business of the evening was the Chairman's ddress, which dealt mainly with the question of Technical nd Industrial Education; afterwards the Chairman ›xhibited, by means of lantern slides, some very fine views ›f the principal educational and technical schools of Europe ınd Great Britain.

Mr. JOSEPH DAVIS, M. Inst. C.E., was then installed as Chairman for the current year, and in the course of a short address to the members, he alluded to the services rendered by Mr. BARRACLOUGH during the two years he occupied the position of Chairman of the Section.

The resignation of Mr. C. O. BURGE, M. Inst. C.E., as a member of committee and of the Section owing to his departure for England was received with deep regret.

The Second Meeting was held at the Society's House, on 20th July, 1905.

Mr. JOSEPH DAVIS in the Chair.

The discussion on the papers on Reinforced Concrete, read by Mr. GUMMOW and Prof. WARREN at the previous Session was entered upon and aroused a good deal of interest, there being present several visitors from other Societies. Messrs. ANDERSON (Hon. Sec. of the Institute of Architects), WALSH, W. E. COOK, C. E. CARDEW (a visitor from Burma),

the Chairman, and the Hon. Secretary, took part in the discussion.

The authors of the papers having replied, the meeting then terminated.

The Third Meeting was held on the 20th September, 1905.

Mr. JOSEPH DAVIS in the Chair.

Mr. HENRY DEANE read a very interesting paper entitled "Notes on a tour through America, Great Britain, and Europe," which was followed by a general discussion participated in by the Chairman and Messrs. P. ALLEN, G. HOSKINS and CARDEW.

The author having replied, the meeting then terminated.

The Fourth Meeting was held on the 14th December, 1905.

Mr. JOSEPH DAVIS in the Chair.

Mr. WHITCHURCH SEAVER, B.E., communicated a paper through Mr. W. E. COOK, on "The Storage and Regulation of Water for Irrigation Purposes," which by permission of the Chairman was read by the author.

A discussion followed in which Mr. McKINNEY dealt with the question of movable weirs and various kinds of modules.

Mr. JAMES DAVIS, a visitor from Colorado, addressed the meeting by invitation of the Chairman, on the storage of water from an American's point of view.

Mssrs. SMAIL and CARDEW contributed to the discussion, and Mr. McKAY moved that the paper be printed and that the discussion be adjourned until next meeting.

The Chairman expressed the thanks of the Section to Mr. SEAVER for a very useful and interesting paper.

The meeting stands adjourned until next Session.

J. HAYDON CARDEW, Hon. Sec.

ANNUAL ADDRESS.

By S. H. BARRACLOUGH, B.E., M.M.E., Assoc. M. Inst. C.E.,
Chairman of the Engineering Section.

[*Delivered to the Engineering Section of the Royal Society of N. S. Wales, 27th July, 1905.*]

SUMMARY.

Introductory—Progress of Section—Choice of a Subject for Address—Brief review of the past three or four years—Directions of engineering progress—Progress of educational reform—Commissioners' reports—Sir P. N. Russell's second gift to the University of Sydney—P. N. Russell Scholarships—A School of Architecture—Surveying—Reorganisation of the P. N. Russell School of Engineering—Future needs—Our position in relation to others—Extraordinary activity in other countries—Correspondence Schools—The late Dr. R. H. Thurston and the Sibley College of Engineering—American progress—The case of Germany—Japan's achievement—The virtue of war—"Sport for sport's sake"—The art of invention—National efficiency—The menace to England—The position of Australia—The urgent necessity for national training—Rational v. empirical methods in industry—Types of labour—Primary and secondary industries—Agricultural education—Education not a luxury—The limits of prudent expenditure—The Morill Land Act in America—The urgency of the question—Conclusion.

Before vacating the Chair custom demands that I occupy your attention for a short time with some remarks of a general nature appropriate to the occasion. In the first place, I have to thank you most sincerely for the privilege of being allowed to serve the Engineering Section for a second year of office. It is needless to state that I do not

assume that the unusual course of re-electing the chairman for a further term of service was on account of any special merits of the holder of the office, still I cannot but be distinctly conscious of the honour you did me and of the cordial good feeling which prompted my re-election.

It is now two years since the Section decided to suspend its regular monthly meetings, and to try and concentrate the papers in two or three special sessions during the year. It must be confessed that it is still open to question whether the scheme has been a successful one or not. In some respects it undoubtedly has; the session dealing with Water Conservation and Irrigation excited a great deal of interest amongst members of the Society and others, and the fact of the extra copies of the papers read at that session having all been disposed of, some to distant parts of the world, makes it apparent that our discussion of the question was considered to be of value. We have this year to decide whether it will be better to continue the sessional idea, or to revert to regular monthly meetings. Probably no alteration in the method of holding meetings will entirely get rid of the difficulty of small audiences which at times besets our Society, and which to a greater or less degree is apparently felt by all other technical and scientific bodies in Australia. The real difficulty consists in the number of societies as compared with the limited number of citizens who take any direct interest in scientific and technical matters. Through the kindness of the secretaries of the various societies, I quote the following figures, giving the approximate membership of the institution and the average attendance at meetings in each case.

Society.	Membership.	Approximate average attendance.
Royal Society of N. S. Wales	345	35
,, (Engineering Section)...	100	25
Linnean Society of N. S. Wales	110	23

Society.	Membership.	Approximate average attendance.
N. S. Wales Engineering Association ...	122	40
Electrical Association of N. S. Wales ...	92	40
Institution of Surveyors	230	15
Institution of Architects	105	15
Sydney University Engineering Society...	170	45

The total membership of these societies is considerable, but no one has yet been able to suggest a method by which their efforts should be more concentrated. We have a certain small consolation at any rate in knowing that the same difficulty besets many, even of the largest scientific societies in other parts of the world.

It is practically certain that we shall at least have one continuous session this year to deal with the subject of scientific and industrial education in Australia. This it was proposed to hold last year, but it seemed wiser to again postpone it until the publication of the Education Commisioners' Report on Technical Education, which it is expected will be ready in the course of a few weeks, the whole of it I am led to understand being now set up in type. The object of this session, in which it is hoped representatives of all other kindred associations will participate, will not be so much to discuss the general question of technical education as an endeavour to discover the proper conditions for industrial and scientific training in this country.

It was at first proposed that the remarks I address to you to-night should be in the nature of an introduction to this session. It has proved, however, more convenient to hold this special meeting for the election of officers and to inaugurate the work of the year, but you will naturally understand that owing to the interest I take in the subject of scientific and industrial education, part at least of my remarks will be concerned with that topic.

In preparing his address the Chairman has choice of several methods. Commonly the address takes the form of an historical summary of the directions of progress during the immediately preceding period. On looking back over the remarks of the Chairmen for the last three or four years, I find that for one reason or another this course has not been adopted, so that no such review has been published during that time. If I do not follow this plan it is not that the period of the few years just passed does not offer considerable temptation for an historical sketch of progress.

Although, doubtless, each generation is inclined to overestimate the value or importance of contemporary occurrences, yet it is hard to believe that even future historians will not regard the present period as one of distinct interest, and at least considerable importance. It has been a period of wars with their marked effect on trade and industry; it has witnessed the close of the struggle of the South African Republics against Great Britain, the last effort as it seemed of the old type of civilization against the new; and it has witnessed the beginning, and may we trust the almost ending of the titanic conflict between Russia and Japan, the first effort as it seems to some of the awakened eastern civilization against the western.

It has been a period of industrial war marked by the growth of gigantic trade trusts and monopolies on the one hand, and the each year more elaborate organization of labour on the other. In England it has witnessed what a few years ago would have seemed the astounding proposal to foster our industries by tariffs, and to threaten neighbouring nations with fiscal retaliation. In Australia it has been the period of early experience with federation, with its inevitable disappointments. It has witnessed sociological experiments on a large scale; the practical prohibition of immigration of industrial workers, the establishment of

compulsory courts of arbitration and the like. It has witnessed previously unexampled illustrations of "spirited public works policies" with other people's money, and sweeping retrenchment schemes when the money was gone. It has been a time of great activity and controversy in educational matters the wide world over and in Australia, and particularly this State, there has been set on foot a movement of vital significance in the direction of educational reform. Finally, it has been a period of marked development in engineering matters, one or two of which will merit slightly extended reference. A very casual examination of this long but still very partial list will show that any of the topics could with advantage be discussed by this Section, but it is only the last two items that time will allow me to mention.

DIRECTIONS OF ENGINEERING PROGRESS.

The one development of a strictly engineering nature to which I will refer on this occasion is that of prime-movers, to which subject I had occasion to give some special attention during a recent short trip to Europe, and there are a few points of progress in this direction worthy of at least passing notice. Steam turbines have more than fulfilled their promise of a few years ago as rivals of the reciprocating steam engine, and it seems to be now the almost universal opinion that no further marked improvement in the older type of engine may be looked for, or indeed is desirable. We may regard for example the reciprocating engines of such a vessel as the N.D.L. Kaiser Wilhelm II. as being the crowning effort of the designer of this type. Indeed it is hard to imagine anything in its way more perfect than these machines.

A good deal has been hoped for from the use of the Binary Vapour Engine as extending the usefulness, and increasing the efficiency of the ordinary cylinder and piston type, by

utilizing through the instrumentality of a second substance the lower temperature ranges, which cannot be effectually worked through with steam as the agent on account of the great specific volume and low pressure of steam at such temperatures. The elaborate experiments by Professor Josse on an engine of comparatively large size, and which in the early part of the year I had an opportunity of inspecting at the Charlottenburg Technical School, have been everywhere watched with great interest. In this engine, as many of you are probably aware, the second working substance was sulphur dioxide, the waste heat from the steam engine proper being used to evaporate the SO_2 which was used as a working substance in a special cylinder. These experiments have now been concluded, but I found that as regards their application to new engines probably not so great a field is available as was at one time thought, as the margin of waste in the primary engine, to be saved in this fashion, is not so great in the modern steam engine as it was in the earlier ones, and hence there is not so valuable a return to be obtained as an offset to the increased complexity necessarily caused by the addition of a cylinder using a second vapour. It is thought, however, that there are many older reciprocating engines already in use of less than modern maximum efficiency which both in efficiency and output might be improved materially by the addition of the extra parts. A fresh set of experiments is about to be undertaken for the purpose of determining what advantage may result from the use of these additional appliances in connection with the waste heat from gas engines, and it is very possible that here a much more promising field is available.

For certain classes of work we may assume that the usual type of steam engine will still be largely used, but there can be no doubt that the steam turbine, in one of its now many

forms, is to be the popular steam engine of the immediate future. It is hard to imagine anything, apart say from a great catastrophe in connection with the new Atlantic liners recently launched with turbine engines—a catastrophe there is not the slightest reason to expect—that can prevent this result being achieved. The prompt introduction of the turbine steamer into the Australian coastal trade is a matter for gratification, and speaks much for the energy and enterprise of the company concerned. The well known turbine types of Parsons, De Laval, Curtis, Zoelly, Rateau, and Riedler-Stumpf, are now being developed in the hands of large companies or syndicates in England, America, and on the continent of Europe, and orders for immense horse-powers are being rapidly executed. In addition to these six types, there are a considerable number of others, perhaps not so well known, but doubtless in a few years the number of types in actual operation will be largely increased. In fact so anxious are the big engineering firms to build turbines, that in addition to manufacturing the better known descriptions on a royalty basis, any new, if promising design for a steam turbine receives very respectful consideration at their hands.

Meanwhile, it is obvious that the steam turbine is to find an active competitor in the shape of the large modern gas engine operated with cheap gas of various descriptions, and the recent introduction of the smaller suction-gas plants has made this a source of power which is very hard to excel from the point of view of economy and convenience. One such plant at least is in operation in Sydney at the works of Messrs. John Sands, and a large plant of a similar type is being installed in New Zealand. It is hoped in the near future to instal an experimental gas producer plant in the P. N. Russell Engineering School at the University, and doubtless also considerable activity in the same direc-

tion will be experienced in many parts of Australia during the next few years. An important application of large gas and oil engines will yet be found in marine engine work, and the question of the special problems in mechanical design for this purpose I found is now being seriously taken up in Germany. Both steam turbines and gas engines still suffer from the great mechanical defect of not being able to reverse. It is true that devices for producing reversal have been suggested in each case, but there is nothing to indicate that the problem has been satisfactorily solved. Meanwhile, it is worth noting that the gas turbine is distinctly looming in the future as the goal of the thermodynamic machine. One type at least of this machine is advertised on the market, and although there are many special difficulties in the way, many designers are working at them, and when the type is perfected and made reversible probably a fairly definite limit will be reached in the direction of apparatus for transforming heat into mechanical energy.

EDUCATIONAL REFORM.

One need have no hesitation in saying that the most important topic, looked at in the broadest sense, to attract recent public attention is that of Educational Reform. This is not the time or place to discuss the general question in any detail, but one or two matters emerge which merit passing notice. There probably has been no period within recent times when so much consideration has been given to the question of education, and its proper organisation. All over the world the matter has been discussed with an amount of detail, and a persistency merited by its supreme importance. The most striking features in this connection in Australia have been the appointment of the Educational Commissioners, one of whom it is gratifying to note is a member of this Section, and the consequent improvement

ı the public attitude towards educational subjects. This reat improvement in the educational atmosphere is one, ! not the most important result already achieved by the 'ommissioners, and is the only reply needed to the objection aised by some that no commission of inquiry was called for.)ne has but to compare the degree of interest now being ›vinced in educational matters, and the intelligence thereof, vith that which characterised the public mind some three ›r four years ago to realise what a marked improvement ɑas taken place. It was previously alleged that no Commission was necessary, as already there was to hand a sufficient amount of information on the educational methods of other countries in the published reports of previous inquiries both by the authorities here and in other parts of the world, but fortunately this erroneous view did not prevail, and the commissioners have vigorously attacked a task much more difficult than that of merely collecting information as to *what* other peoples are doing, viz.—of determining *why* they are doing it, and so endeavouring to discover what are the right methods for this country to adopt to meet its own particular needs. No scheme of education can be imported ready made, and wholesale, from even the best educated country in the world.

We may trust that one direct result of improvement in the educational atmosphere of the community is that we have once and for all got rid of the idea—"Ours is the best in the world." It had so long and so often been reiterated that Australia had little to learn and much to teach, in the matter of education, that one of the first steps necessary for real progress was to obtain such a view of the educational position of other nations that we should realise how very far indeed we were from occupying so enviable a position, and in this matter the commissioners have been distinctly successful.

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A SCHOOL OF ARCHITECTURE.

One addition to the engineering department for which a great need exists is that of a properly organised school of architecture. At present a short course of lectures on building construction and the history of architecture is given to certain of the students, but neither at the University nor the Technical College, nor indeed in any part of Australia is a comprehensive scheme of instruction for men desiring to follow this great profession to be found. Nothing indicates the character and taste of the community more than its buildings, and these again in their turn react in the development of the taste of succeeding generations. Few things are more worth a people's while than to live in the "House Beautiful." I do not for a moment argue that we have not in Sydney many fine architectural examples, not only in some of the larger buildings, public and ecclesiastical, but also in the more limited sphere of house architecture. The community indeed has a good deal to be thankful for when it is remembered that practically no thorough and systematic attempt has been made to train the designers of these buildings. In the early days there were two or three men, whose names should never be forgotten, who left behind them public buildings which are monuments to their artistic skill and constructive ability; and the effect of these buildings in setting a standard cannot be over estimated in importance.

Succeeding these few masters came a number of men trained in the better established schools of the Old World, who did much to beautify the city, and their pupils are now, in many instances, ably supporting the best of the early traditions. But it must also for truth's sake be confessed that with this there is a woeful quantity of the worst kind of architecture to be seen in all directions, and it is folly to hope that, unless definite steps are some day

taken for the training of the architects of the future, the average of building can ever rise beyond the mediocre. At present it is greatly to be regretted that, side by side with buildings in the city evidencing the skill, taste and power of initiative of the designer, huge structures are erected—their very size making them monumental—which transgress almost every canon of art, architecture, and engineering.

While referring to matters architectural it will not be out of place to incidentally record the admiration which everyone interested in technical subjects must feel for the enterprise, no less than the skill evidenced by our confreres of the Institute of Architects in publishing their bi-monthly journal "Art and Architecture." Not only for its matter and illustrations, but even as an example of the printer's and publisher's art, it merits nothing but praise. One cannot but hope that it will have an increasingly liberal support, not merely from professional men, but from the general public.

SURVEYING.

Another subject to which I am glad to see attention has several times of late been drawn, is that of instruction in surveying. This is a subject which peculiarly lends itself to systematic instruction such as may be organised in an engineering college, and it is hard to see that anything but good could result from the organisation of a complete course of training in that subject at the University. It is not of course possible to produce by any such curriculum a professional expert in surveying any more than in any other subject. Some subsequent experience would of course be necessary, but the naturally haphazard instruction obtained during pupilage has even less to recommend it in the case of so precise a subject as surveying than in engineering or architecture.

a delay in providing the money, and meanwhile the work of the school is greatly handicapped.

OUR POSITION IN RELATION TO OTHERS.

After thus briefly noticing some of the signs of progress and movement in our local educational world, it is not out of place to remark that progress is a relative thing, and that the essential question is not, have we made an advance? but rather, has our rate of progression kept pace with that of other countries? And from this point of view the outlook is not so promising. A short visit to Europe a few months ago only served to emphasise to my mind the fact that in the matter of engineering and technical progress, and in industrial training we are distinctly falling back. One is impressed with the fact that there is

EXTRAORDINARY ACTIVITY IN OTHER COUNTRIES.

Indeed, in noting the signs of progress in German institutions during the last two or three years one cannot help a slight feeling of depression on realising the almost impossibility, as it seems, of keeping our institutions proportionately abreast of theirs. Even England, although herself in not too enviable a position, is leaving us distinctly behind, which could not be said ten or twelve years ago; and in America it is almost impossible to keep oneself informed of the rate of progress, and of the colossal sums that are being invested in scientific and industrial training. I propose to attempt no sketch of this progress at present, but as indicating the very genuine interest which is taken in the subject I would like to call your attention to the fact, probably not known to all, that there is a society in America, of which I have the privilege of being a member, devoted entirely to the consideration of the one subject of the promotion of engineering and industrial education. This society has now published 12 annual volumes of papers and discussions, covering the whole field of education for

school a complete refrigerating plant, which is now being installed and includes a steam driven ammonia machine and a small set of ice tanks and refrigeration chamber. In both America and Germany the large manufacturing firms have shown great generosity towards the engineering and technical schools in the matter of presenting them with typical examples of the products of their works. It is there recognised that this practice is to the benefit of both the firms and the Universities, the latter having the advantage for instructional purposes of modern types of machinery, while the former have the satisfaction of knowing that the students, who are to be the future engineers, are obtaining an intimate knowledge of the special virtues of their machines. Several other firms in the city have also been kind enough to lend pieces of machinery or apparatus for the instruction of the students, for longer or shorter periods.

PROGRESS OF THE SCHOOL AND FUTURE NEEDS.

There have now passed through the Engineering School something over 150 graduates, and there are about 80 undergraduate students in engineering on the University roll. Notwithstanding the dullness of trade and the absence of many great engineering enterprises in the community the great majority of the graduates have obtained satisfactory employment, and a considerable number are occupying responsible positions. They are very widely scattered however as regards location, and the greater part of them are not occupied in New South Wales, for reasons which it is unnecessary here to elaborate.

Very much remains to be done. The most urgent need at the present moment is the new building, for the erection and equipment of which the State Government have agreed to contribute £25,000 in compliance with a stipulation made by Sir Peter Russell. Unfortunately, however, there seems

a delay in providing the money, and meanwhile the work of the school is greatly handicapped.

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engineers and for industrial workers, and by means of special committees is engaged upon important inquiries in regard to professional education in directions in which there have been controversies.

CORRESPONDENCE SCHOOLS.

As an indication of the extraordinary demand that exists for technical instruction of various kinds it is not inappropriate to instance the institutions known as *Correspondence Schools*, and this more especially as they have recently been introduced into Australia, and already have attracted a good deal of support, especially, I understand, from people in country districts who have not the advantage of a regular college in their neighbourhood. These schools have sprung up like magic in America during the past ten years, and although some refuse to regard them seriously, are now thought by many to be serving a great need. Whether they will remain in demand, or are only a passing phase of educational opportunity, may be questioned. Until other opportunities of acquiring a technical training become practically universal, however, the evidence is already clear that they will find a great work to do. The fact that a single one of these schools has now on its roll of students several hundred thousand names is the best possible proof of the great demand for technical education. These schools supply their students with specially prepared text-books and pamphlets, and have developed systematic methods of imparting instruction by correspondence—a system indeed organised to a pitch of elaborateness and efficiency that commands the admiration even of those who criticise the method.

THE LATE DR. R. H. THURSTON AND SIBLEY COLLEGE.

As no earlier opportunity has occurred of mentioning it I cannot let the occasion pass when speaking of educational work without referring to the death which has taken place

during my term of office of my sincere friend, and one time instructor, Dr. R. H. Thurston, the Director for 18 years of the Sibley College of Engineering at Cornell University. Although probably not generally known to the public of this country, his name was a household word amongst engineers and educators in America and Europe, both as a professional man, and an expert in educational matters. He has not inappropriately been called the father of the modern engineering school. As a young man he passed through the engineering workshops, took an arts degree at the University, entered the Engineering Corps of the U.S. Navy, and served all through the Civil War; and afterwards occupied a chair in the Naval Academy until in 1870 he accepted the then rather novel Professorship of Mechanical Engineering in the Stevens Institute of Technology, where for 15 years he laboured in developing, what was for its time, an unusually efficient course of instruction. Indeed his syllabus of instruction of that early date is in many respects a model even for to-day.

In 1885 he was called to be the first director of the Sibley College of Mechanical Engineering at Cornell, and began, what he rightly felt to be, the great work of his life. Starting as it did from small beginnings, and a few dozen students, he had the great reward for his labours of seeing the College, with its now more than one thousand students and its splendidly differentiated courses of instruction, develope into what, even at the risk of being considered biassed, I cannot but describe as one of the finest pieces of organisation in engineering education in existence.

Amidst the multitudinous duties of so great an office, he had that highest of all arts of seeming and being always a friend to the many thousands of students who came under his care. Their wants always claimed his ready attention; their letters years after leaving college were always

promptly and sympathetically answered, and their interests were never forgotten. He died, suddenly, as I have occasion to remember, on his birthday and mine, as he sat in his study chair at Cornell. Fittingly enough the sum of £50,000 is being collected to erect a memorial laboratory for research in engineering to his memory, but such benefactors of his race as he, require no monument.

SIBLEY COLLEGE.

This is not the place to discuss in detail the organisation of the Sibley College of Engineering, although on a fitting occasion few subjects might more usefully be considered. Perhaps if it needs any expression of commendation it may best be had by reminding you of the great success which the University of Birmingham in England is achieving, and which, as is unstintedly admitted, obtained its inspiration largely from Cornell and Sibley. Sibley College was one of the early departments of Cornell University to be established, and accorded well with the ideal of Ezra Cornell, the quaint, shrewd man of business, of rather the old type, who conceived the idea of founding a great and truly democratic University; and though perhaps it lacks a certain glamour that attaches to the older New England Colleges, such as Harvard and Yale, whose history goes back to the early Puritan days, yet from a fairly intimate knowledge of all three, I venture to think that nowhere is the democratic ideal of American education better illustrated than in the Cornell of to-day. The University begins to realise, at least in some degree, the hopes of its large minded founder, who remarked in words which sound, in their simplicity, plain, but which embody a very noble thought, "I would found here an institution where any person may receive instruction in any subject." "Cornell," said a well known English educator—Principal Fairbairn of Mansfield College, Oxford—"is an example of a University

adapted to the soil, bravely modern and industrial without ceasing to be ancient and classical, or philosophical and historical."

Before leaving this subject, there are two policies pursued by the authorities at Sibley College which must commend themselves to every engineer, and which I personally trust it may be possible some day to embody in our own University. They are two policies which aim at keeping the engineering department in close and intimate touch with the actual practice of the profession outside.

The first is, to have each year a carefully organised set of lectures delivered by experts in the different branches of the profession to the students attending the regular college courses. This practice has the double advantage of enabling the experts in the profession to obtain a sympathetic insight from time to time into the organisation and working of the school on the one hand, and on the other hand it allows the students to become acquainted, at least by sight and voice, with the leaders of the profession which they aspire to enter. The second policy, which has recently been brought into force, is to insist upon the necessity of professors and lecturers keeping in active touch with the practice of their profession, and for this purpose leave of absence is to be granted at fairly short intervals, for a year or even two years to the members of the staff for the purpose of enabling them to resume for a time their professsional practice.

One of the chief competitors of the Sibley College as a place of training for engineers is the Massachusetts Institute of Technology in Boston, and it is worthy of note that this institution during the last few months has become amalgamated with the Applied Science Department of Harvard University, the ultimate aim doubtless being to attach the great school of engineering and technology,

which will thus result, to the Harvard University as one of its constituent parts. Both these institutions already were possessed of large endowments and were provided with an elaborate staff of instructors, and housed in splendid buildings, but as I learn from a letter received a week or two ago from a member of the Harvard staff, they are about to receive the first instalment of a huge bequest, which will almost immediately yield an income of £10,000 a year, and as various annuities lapse their income from this one source will finally reach the magnificent figure of £100,000 a year. In view of these circumstances it is proposed to abandon the present buildings of both institutions, and to erect a magnificent pile in a locality where more room is available. When this is done it will probably be the most perfect institution of its kind in America.

Yet another plan worthy of special note is the arrangement recently made by one or two American and German Universities for the interchange of professors for periods of a year at a time. Nothing could be more stimulating to all concerned than such a scheme.

AMERICAN PROGRESS.

However it would be a hopeless task to attempt to enumerate, even in outline, the great achievements of the American schools during the last few years. They are now to be counted in very fact by the score, and set the British nation, and I think Australia in particular, an example which they should endeavour to emulate. It may be replied of course and with a certain amount of justice that America with her vast opportunities and immense natural resources cannot under ordinary circumstances avoid achieving large success. In a sense this is true. It is doubtful if ever before in the history of the world, man had such extraordinary opportunities for material good as in North America. As it has recently been put, and with

some justice—"Nowhere else on the face of the globe is there such a land. With a soil of exhaustless fertility if properly cultivated; with original forest resources sufficient to supply the world for centuries; with an almost infinite energy stored in the ample coal beds, and in the oil and gas deposits, which are almost co-extensive with their territorial limits; with the richest iron ores so plentiful and abundant as to make their value scarcely more than common rock or earth; with copper, lead, zinc, gold, and silver deposits in marvellous quantities; with a climate all that could be desired and nowhere equalled for agricultural purposes; and finally, but most of all, peopled by the most progressive races under the sun; with all these infinite opportunities, surely something should have been accomplished." But even admitting all this, it is a sorry argument that because natural opportunities are less, a people therefore is to be excused from making an equal effort. It has yet to be shown that this country is not possessed of as fine possibilities as America, and if, as is evident, the resources of the country are not quite so readily to hand as in the United States, it is surely all the stronger argument for a resolute and determined exploitation of those resources.

THE CASE OF GERMANY.

No such argument, however, applies to the case of Germany, which during the last century, has shown how in the face of obstacles that a less courageous and wise people might have regarded as insuperable, a nation may bring itself from a position of apparent ruin to the very summit of international success. The history of this development has already several times been referred to in the recent educational discussions, so I will merely content myself with pointing out that within 12 years of the date of the Franco-Prussian War, a Royal Commission from England,

after a most careful study of the situation, reported that England had everything to fear and many things to learn from her new rival. "The situation," says a friendly critic, "becomes annually more acute and to-day England is realising the risk that she runs of losing possibly for ever her position as the leading manufacturing and commercial nation of Europe."

The explanation of this remarkable transition is deserving of the most careful study, and it is of peculiar interest to the members of this Society. As an American writer[1] has recently put it, "That an interior country like Germany, without a navy, and with little foreign commerce, could in a quarter of a century by increasing her manufacturing capacity tenfold make it equal to that of England; increase her shipping twenty-fold, making it second to that of England; effectually establish a regular export trade with every country on the globe, and by at once cheapening products and improving their quality, put herself in a position to hold these markets indefinitely; that all this could be accomplished in the face of open competition, and in this age of universal publicity, is indeed marvellous, and would alone prove that old methods have lost their potency and that something new has arisen under the sun."

JAPAN'S ACHIEVEMENT.

But if the case of Germany is remarkable, what can be said of Japan which almost within the space of a single generation has progressed from mediævalism to modern civilization. However puzzled we may be by the spectacle, and however dubious as to the value of the civilization, it would be the worst folly to miss the obvious lesson of so extraordinary a national performance. It is in a very striking degree an illustration of deliberate adaptation of means to an end; of national organisation on a large scale,

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[1] Prof. Johnston, Vol. VI., Proc. Soc. Prom. Eng. Education.

and with unparalleled efficiency; and of a zealous loyalty and patriotism that no obstacle could thwart. To emphasise the spirit that animated these neighbours of ours in the North, I cannot refrain from quoting two remarks made by the Mikado, when in 1872 the government promulgated the complete scheme of education which was part of the plan that aimed at placing Japan in the first rank of civilised peoples. The Emperor said in words which are worthy of oft repetition :—"It is intended that henceforth education shall be so diffused that there may not be a village with an ignorant family, or a family with an ignorant member. Persons who have hitherto applied themselves to study have almost always looked to the Government for their expenses. This is an erroneous notion proceeding from long abuse, and every person shall henceforth endeavour to acquire knowledge by his own exertions." It is impossible to know which to admire most, the first sentiment or the last.

The long list of primary and high schools, technical and trade schools, colleges for medicine, for agriculture, and for veterinary science, for commerce, and for the fine arts; institutes for training teachers and technical instructors; and last, but not least, the great Universities of Japan testify to the zeal and success with which the task has been carried out. The result of the present war, even before its conclusion is reached, is only a fitting climax to such efforts by such a people.

THE VIRTUE OF WAR.

It is Ruskin, I think, who points out that sometimes the blessings of war overbalance its curse. Indeed it is not hard to realise that there are worse things than war. Even making allowance for the colossal material waste, the hideous loss of life, and the almost unimaginable suffering, who could deny that the present war is a blessing to Russia,

giving her people as a whole an opportunity that might otherwise not have offered itself again for generations, of escaping from a tyrannical bondage and becoming actually the great nation they are potentially. And not less is it a benefit to Japan, testing her qualities, proving her powers, enlightening the minds of the people, and confirming them in the wisdom of their long preparation, and still further preparing them for their great destiny.

Further, will anyone lightly deny that looked at from a national point of view, one of the most bracing experiences that could befall us as a people would be the presence of an enemy at our gates. Nothing could more quickly reduce matters to the basis of a reality they at present lack. Nothing would more readily convince that large and possibly major section of the community whose ideal may be not unjustly stated in the motto, "Sport for Sport's sake," that especially in a democracy such as this, national success can be achieved only through the responsible and deliberate efforts of the citizens.

THE ART OF INVENTION.

It may seem on casual consideration that it is a matter of small moment whether (so long as a worker perform his labour faithfully), he works with pleasure and zest in the task, or merely as a means to subsequent amusement, but this argument will not bear close examination. Professor Reuleaux, one of the greatest of all the German engineering educators, has shown in an admirable passage that the process of invention, and of industrial discovery is not, as is popularly supposed, a haphazard matter. Inventions rarely come as flashes of intuition or as accidents, but are the results of long cogitation and rumination, and this none the less so because the inventor subsequently is not himself always conscious of the various steps by which he arrived at the result. Now these processes of thought are

absolutely essential to industrial improvement and advancement, and if this zest for labour, this inspiration of toil is lacking in the worker of all grades (it applies to the highest as to the lowest) much progress cannot be looked for.

The British people have been, and are, great inventors. It was an Englishman—or at any rate a Scotchman—James Watt, who nearly one and a half centuries ago produced the steam engine in a practicable form; it took other nations half a century to get proper possession of it, so to speak, and to this fact our past material prosperity is to a considerable extent due. It is equally true that it was an Englishman—or at any rate an Irishman—who produced the steam turbine in a practicable form some 20 years ago, but in these days progress is fast, and not 10 years were required for other nations to have full possession of it. To-day, more Parsons steam turbines are built out of England than in it.

NATIONAL EFFICIENCY.

The methods of the past will not serve. They were good, but something more efficient is now required. It was Lord Rosebery who in a remarkable speech a few years ago put this matter with great emphasis, and set forth the position that the vital question now confronting Great Britain was, whether she intended abandoning her ancient policy of "muddling along," and substituting for it that of "efficiency." National efficiency, the adaptation of means to ends, is what is lacking at present in our Nation. For the time Australia's prosperity, commercial and industrial, is largely bound up with that of Great Britain, and the important question for us is whether our methods display this quality of "efficiency." It would not be hard to establish the fact that at present they largely do not. Without going into such a discussion in detail, I think it is a fair comment to make that the three public Commissions

of Inquiry recently appointed, are somewhat striking evidences of the inefficiency of our method of doing things. I refer to the Cataract Dam Commission, the Lands Inquiry, and the recent Butter Commission. It would not be proper to-night to discuss anyone of these three, more especially as two of the matters are *sub judice*, but the fact of such inquiries being necessary cannot but demonstrate that in the three important directions of public works, land settlement, and commerce our system, regarded from the point of view of benefit to the State, lacks efficiency.

THE MENACE TO ENGLAND.

I think it may be agreed that England has lately distinctly recognised the menace to her position, and is now bestirring herself with considerable vigour to meet the enemy. She has proposed two distinct lines of effort. The first is the improvement of her system of scientific and industrial training, which everyone will admit to be a sound and safe path. The second, is the proposal of a considerable section for retaliatory tariffs, which some may fear is a weapon of the boomerang order, but in any case is certainly not proper for discussion this evening. The evidences of an attempt to improve the educational system in England are many. For instance, the fact quoted by His Excellency, the State Governor, in a public speech the other evening, that the expenditure on technical education by the London County Council had increased during the last 10 years from only £4,500 a year to over £300,000 per annum is most striking; and I should also have liked to refer amongst others, to the splendid equipment and organisation of the Manchester School of Technology, and of the Birmingham University, both of which institutions are on the best modern lines, and in different directions.

THE POSITION OF AUSTRALIA.

Meanwhile, what have we been doing here during recent years? One can only say we have been virtually standing

still for 10 years past. After the erection of the present Technical College buildings, the State seemed to have temporarily exhausted its efforts, and beyond a very small increase in the expenditure, and the loyal efforts made by the authorities and teaching staff of the Technical Colleges to improve the conditions here and there wherever the limited means at their disposal allowed, we have done little in the direction of planning a systematic scheme of instruction. At present it is only recording a fact of the case to state that there is no co-ordination between the various technical institutions, either with primary and secondary education on the one hand, or with the University on the other, nor yet with the industrial life of the community which technical education should foster and encourage. There has been no elaborate and consistent planning of means to this definite end, no adequate preparation for taking our right place, nor even for sufficiently defending ourselves in the industrial war of nations. That such a state of warfare exists it is impossible to deny. No friendly treaties can prevent it, nor is it easy to see how peace can be secured. The relations between civilised nations are much more primitive than between civilised individuals. It is not an army of soldiers that constitutes the real menace in these days, but the regiments of scientifically trained directors of industrial enterprise, the armies of intelligent mechanics and artizans.

Although all nations may, in the words of an ancient writer, "turn their swords into ploughshares, and their spears into pruning hooks," yet if the spirit of competition still remain, the weapons, even in their tranquil disguise, are just as formidable. The only defence in this kind of strife is to reply to action with action; to meet education with training, and excellence with yet more. "Captains of industry," says Carlyle, "are the true Fighters, henceforth recognisable

as the only true ones." The situation is complicated by the fact that there is dissension in the camp. There is discord in our midst when all should be united to meet the keen competition of other nations. Our efforts are largely negatived by our domestic quarrels. Class is opposed to class; labour is opposed to capital. We have monopolies on the one hand, attempts at State socialism on the other. Equality of opportunity is demanded by some; equality of reward required by others. In endeavouring to solve the problem of training a nation in the arts and industries, these difficulties must necessarily be taken into account. It is quite evident that 'Demos' for better or worse is in power, and that permanently. But properly interpreted this may be, and I think should be, regarded as a great ground for hopefulness. As a recent writer has put it—"In our modern democracy the nation has called out its last reserves, and its success or failure must depend upon the action of the great body of the citizens, and not upon any small class of them." Once this is realised the urgency of the proper taining of the great bulk of the people which must and should be in the direction of industrial enterprise, is only made more evident.

THE URGENT NECESSITY FOR NATIONAL TRAINING.

The pressing necessity which should weigh upon the mind of every statesman, and every man in any public capacity, in fact upon every citizen should surely be this one of providing that adequate scientific and industrial training for the nation, which for convenience we commonly refer to as technical education. We at present have no systematic scheme for training the great bulk of the people for 'the sequel of their lives.' We have tacitly agreed with most other nations that apprenticeship is dead, and have virtually abandoned apprenticeship as a system, but have substituted nothing for it. We are right to assume that

apprenticeship as a system of instruction is no longer adequate to modern needs. "When industrial capacity rested wholly upon tradition and empirical knowledge, and upon manual skill, it was absolutely essential that artisans should obtain all this knowledge and skill as apprentices in the shops and mills as manual helpers, and as unintelligent copyists. But since nearly all processes of the artisan have now a scientific and rational basis, and the work is done by machines which are the embodiment of the highest type of human reason and understanding, and since the machines require an almost equally intelligent oversight and direction to produce their largest output, and furthermore, since the new discoveries of science require continued changes in materials and methods to keep abreast of the times and to hold the market, and entirely new industries are daily established, founded on some new discovery or invention, and since the demand no longer determines the supply, but new and improved supplies are constantly creating their own demands in all lines of industry, it is evident that the efficient direction of any industry to-day demands a very large amount of technical knowledge which cannot be learned at the bench or in the shops. While self education is always possible, the obstacles are commonly prohibitive, and at best the results are meagre and unsatisfactory."[1]

RATIONAL *versus* EMPIRICAL METHODS.

But it is necessary to substitute a rational system of instruction for an empirical one. The modern position is that scientific investigation is the basis of industry, and that systematic training of the workers is the proper method of extending and developing it. This in no way denies the value of experience, but it should be pointed out that experience is simply the experimental method

[1] Prof. J. B. Johnson.

applied in a haphazard and costly fashion. Much has been accomplished doubtless in the past by the trial-and-error method, but this must more and more give way to the modern and rational one.

All this is true, and only emphasises the necessity for adopting some better system than we have. There is indeed an added reason for us in Australia to amend our systems of training. In this country, whether it is expressed in so many words or not, a distinct ideal of a great section of the community is, that there shall be short hours of labour, high rates of pay, and a limited number of workers and a limited output by the workers. In so far as these desires imply a determination to prevent sweating and civilized slavery, and the maintenance of a decent average of living in the community, they must command the support of everyone, but it is obvious that these ends cannot be achieved by enactments of Parliament, or decisions of Industrial Courts. The only possible means of making such schemes practicable is an extremely high efficiency of the workers. This country in truth cannot afford to have unskilled labour in its midst. So obvious is this statement that it seems almost gratuitous to suggest it, but thus far no attempt has been made to put any such scheme into practice. The providing of an adequately efficient system of industrial, scientific, and technical training for every man and woman in the land, who cared to avail themselves of it, would seem to be a natural corollary of our national conditions and system of living. To use a very technical phrase, one would expect to find as a marked 'plank' in the programme of any party that assumed to legislate for the industrial workers of a community an insistance upon the steady and progressive organisation of such a system of national training. Personally, I should not be surprised to see this question obtrude itself actively into politics.

Lately, it is true, we have in this State—and we are to be congratulated on doing so—taken what may prove to be the first step in this direction by establishing the office of Director of Technical Education, and appointing thereto a man admirably fitted to reorganise and supervise such a system, but this is only the beginning. To instal and maintain the system will cost large sums of money, much larger than anything that has hitherto been provided. The great point which everyone interested in the matter should endeavour to make is that such expenditure should not be grudgingly allowed as if in deference to the clamour of a section of the community, but that it ought to be entered into with the whole hearted support of every enlightened citizen who desires that this people should gain and keep its rightful place in the community of nations.

To argue that the country cannot afford the expenditure necessary for such training, or to express doubts as to the ultimate result of such training, is as irrational as for a farmer to affirm that he cannot afford the wheat with which to sow his land, and has not the patience to wait for the crop.

TYPES OF LABOUR.

In order to give precision to my concluding remarks it will be sufficiently satisfactory to divide the workers of the community into three clearly recognisable, although not sharply defined types, viz.:—

(*a*) The artisan type, merging gradually from the practically unskilled labourer through various types of skilled workers to

(*b*) The foreman type with opportunities and occasions for advancing to

(*c*) The professional and scientific type,

and this division holds satisfactorily both as regards the primary producers in the great primary industries, and the secondary or manufacturing industries.

There seems little room for doubt that a people constituted as we are, must and should develop first and principally our primary industries, and those secondary industries which are connected therewith, and to this end it would be definitely false economy to put any limit to the expenditure of any sum necessary for the attainment of this end. No good reason can be alleged why in the course of time, and very largely now, Australia should not be absolutely unexcelled in the world, not only for such fundamentally important products as wool, wheat and meat, but also for such staple commodities as sugar and wines, dairy produce and fruits, as well as for timbers and leather and the great minerals. That we are not at present in this satisfactory condition will be sufficiently evident to anyone who has carefully perused the reports of our commercial agents published in the press during the last two or three years.

AGRICULTURAL EDUCATION.

In this connection it will not be out of place to refer to the Hawkesbury Agricultural College, in which, owing to having been examiner in mechanical subjects for a number of years, and to various visits to it, I naturally take a great interest. It is no detriment to the undoubtedly good work done by this institution—probably the best of its kind in Australia—and to the marked effect it has had on farming in the State, to say that it is far indeed from being what it should be in a country with such vast agricultural possibilities awaiting development as Australia, and such intricate problems needing solution. The usual course is limited to two years, and every alternate day is spent in actual field work. The time available for work within the college is thus limited to the equivalent of one year. The effects produced upon students, who often enter with a preliminary education of a not necessarily high order, can-

not be expected to compare with those obtained in, for instance, the best class of agricultural college in America, the course in which occupies four years, and in which very often a student is required either to have had experience in farm work before entering the college, or to obtain it during the vacations.

One further remark seems necessary, although I do not know if the statement will meet with the approval of either the one department concerned or the other, but I can see no sound reason why agricultural education should not be under the supervision of the Department of Public Instruction, and this more especially since it is proposed now to re-organise the scheme of technical instruction in this State. It would appear to be almost obvious that the expert knowledge necessary for the direction of such a fundamentally important educational institution is to be looked for rather in a department specially devoted to education than to any other. This would make it possible to co-ordinate the instruction given in the Sydney Technical College and the various country branches, with that to be had at the Hawkesbury College and the Experimental Stations. At present there appear to be several subjects that are taught in common at the two institutions, and there appears to be room for possible overlapping, and consequent inefficiency and lack of economy in the scheme of instruction from the point of view of the State. To have both under one department would also make possible the utilising of the country technical colleges for instruction in agriculture and mining, which would seem to be largely their proper sphere. Sound instruction in these matters must pay as a national concern. The highest class of instruction is not a luxury which can be limited, or even dispensed with when funds are low,—it is a national investment, the return from which it is hard to overestimate. Even

lavish expenditure towards this end is amply justified, quite as much so as for roads and bridges.

THE LIMITS OF PRUDENT EXPENDITURE.

It would be a very interesting question for discussion as to what the limit of efficient expenditure for national education really is. How much in fact would it definitely pay a people to invest yearly in the training of all its members, and what are the conditions that set an economic limit to this expenditure? Without attempting to solve such a problem this evening, it is perfectly safe to say that much more can be economically expended than has yet been the case by even the most lavish nation. I would ask in all seriousness what would be the result if a country like England, specifically decided to invest £100,000,000 during the next ten years in the scientific and industrial training of her people? It may be replied that such a project is chimerical, and not worth discussing, but the essential reasonableness of the proposal is more apparent when compared with the spending of £250,000,000 in three years on a war, which however necessary, produced little direct commercial return, and could only be justified, as I believe it was justified, on other grounds. But is the case different with education? Is it not providing a people with ammunition much more effective than powder and shot both for attack and defence in the modern strife of nations?

THE MORRIL LAND GRANT ACT.

The United States, alone, in its legislature seems to have conceived a scheme, if not precisely along the lines suggested at least with equal enterprise and large hearted courage. Few people would appear to be aware that in 1862 by the passing of the Morrill Land Act the United States Legislature made a colossal effort towards putting the industrial training of the nation on a permanent and liberal footing. They dedicated an area of over five hundred

millions of acres of State lands, from the sale of which there should be established a perpetual fund, "the interest of which shall be inviolably appropriated by each State which may take and claim the benefit of this Act, to the endowment, support, and maintenance of at least one college, where the leading object shall be, without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as are related to Agriculture and the Mechanic Arts, in such manner as the legislatures of the States may prescribe, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life." The Act forbade the use of any portion of the aforesaid fund, or of the interest thereon, for the purchase, erection, or maintenance of any building or buildings; but the several States claiming and taking the benefit of the provisions of the Act were required, by legislative assent previously given, "to provide, within five years, not less than one college" for carrying out the purposes of the Act.

These Land Grant Colleges of the United States are the product of one of the grandest examples of statesmanlike legislation that the world has yet seen. "Like all great enterprises having for their purpose the benefit of the people by legislative enactments, this failed of complete success through the indifference and folly, and the absolute stupidity of many of those public servants to whom its operation was entrusted; it has, nevertheless, produced incalculable good, both directly in the foundation and partial support of technical education, and also partly through its influence upon the States, inducing them to take up and carry on the work from the point at which the General Government left it."[1] Since the passage of the Morrill Land Grant Act in 1862 there has been a steady

[1] Prof. R. H. Thurston.

development in America of the system of State Universities as the apex of the educational pyramid, and also in the lower planes, of more general and effective support of primary and secondary education.

THE URGENCY OF THE QUESTION.

In the foregoing discussion I have avoided details; these we can consider later at the conference on scientific and industrial education, which it is proposed to hold shortly, and from which I trust some very definite results will follow. I have ventured to put these suggestions before you as I am profoundly convinced that the question of the systematic training of the great bulk of the people in the industries, arts, and crafts suitable to this land is from an economic point of view the most urgent and imperative consideration of the time. This is a matter that cannot be accomplished in a day or a year, nor indeed many years, but our national happiness and prosperity depend largely upon the efforts we make to achieve this end. It is one of the duties of a Society such as this, and of all the other kindred institutions to endeavour to stimulate and to guide public opinion on these questions.

Before concluding, and in order to prevent misunderstanding, there is perhaps one further remark I should make. It may have appeared that I have described technical and industrial education from a purely utilitarian point of view, and not from the general educational standpoint, but I should like to make it very clear that in my opinion technical education is infinitely more than a preparation for the earning of bread and butter; in fact as regards its effect on character, I venture to think that in a great many cases it may be more truly educative than much that is popularly so described. Technical education begins essentially in the Kindergarten, where the mind of the child is tempted out as it were, it is continued in any

proper system of primary education in which the faculties rather than the memory of the boy or girl are evolved, and in its later aspects of definite training for a trade or industry it developes the mind, and should ennoble the character. A man who has been so trained that he has a zest for his work apart from what reward he obtains for it, and who realises his obligations as a producer in the State, and whose experience with men and the concrete things of life has made him conscious of his own responsibilities and the rights of others has received the best of educations.

It now only remains to me to express again my very genuine appreciation of your cordial co-operation for the two years during which I have been privileged to serve as your Chairman, a service, the deficiencies of which none can realise more keenly than I do, and to welcome on your behalf my distinguished successor, under whose experienced guidance the Engineering Section is assured of an interesting and permanently valuable session.

SOME NOTES ON THE STORAGE AND REGULATION OF WATER FOR IRRIGATION PURPOSES.

By T. WHITCHURCH SEAVER, B.E.

[Communicated by W. E. COOKE, M.E.]

[*Read before the Engineering Section of the Royal Society of N. S. Wales, December 14, 1905.*]

THE more general and popular questions of Water Conservation and Irrigation, have of late years been much discussed, and from the valuable information which has been collected, with reference to river discharges, location of irrigable areas, and so forth, a clear insight into the whole matter may be obtained. Some time ago several valuable papers were read before this Section, upon such subjects as the equitable distribution of water, property in water, and the chemical nature of soils, besides one which gave a general review of the progress of water conservation in this State. The authors showed that a large amount of water, which, being drained from our own catchment areas, was the sole property of this State, and now running to waste, should be conserved and distributed, and they indicated how this could be done, by the construction of storage reservoirs and diversion channels.

All water conservation and irrigation works may be classed under two general headings of :—

1. Storage. 2. Regulation.

Of these the first may be divided into :—*a* Run-off; *b* Main Storages; *c* River Storages; and the second into works connected with the :—*e* Controlling; *f* Raising; and *g* Conveying of the water.

Even amongst those whose business it is to deal with such matters, it may be doubted if the enormous waste of

our river waters is fully appreciated. Two-sevenths of the waste flow of the Murrumbidgee, said Sir Samuel McCaughey, would irrigate $2\frac{1}{4}$ million acres of cereals, which in his opinion would give a return of nearly £9,000,000. In the County of Cumberland alone, if the water now allowed to run to waste was fully utilized in growing fruit and vegetables, the amount of almost £700,000 now sent out of the State for the purchase of these commodities would be saved.

The most important matter in connection with storage works is of course the run-off from the catchment area, or rather, the amount of water that can be drawn from the reservoir, which will of course, be equal to the inflow, less the loss from soakage and evaporation. Roughly speaking, we may assume that 20% of the rainfall will find its way into the reservoir, and that the annual loss will be equal to about 7 feet off its top surface.

As an example of an extremely small run off, I may mention that at the Junee Storage dam with an annual rainfall of 27 inches, falling on a slate rock catchment of 1,500 acres, there seems to have been only $\frac{1}{200}$ part delivered into the storage reservoir. In fact the supply has proved so bad, that I understand, a second reservoir is to be constructed. That this run off is abnormally small, will be seen if we compare it with the following case: At Nagpur in the Central provinces of India a tank catchment was $6\frac{1}{2}$ square miles of low basalt hills, a fall of $2\frac{1}{4}$ inches took place in 80 minutes during one month of June, and no flow took place, the total rainfall for that month was $6\frac{3}{4}$ inches, of which what was considered to be the remarkably small flow of $\frac{1}{16}$ part flowed off.

In the Deccan district of India the rainfall being much the same as Junee, and the nature of the catchment no better, 114 observations of the run off into tanks were made and the following results tabulated, on:—

26 occasions the flow was less than	10	per cent. of the rainfall.
44 " " " between 10 and	20	
25 " " " "	20 and 30	
19 " " "	above 30	

STORAGE DAMS.

Storage dams are of two kinds, still water dams which are designed to hold water up to a fixed level, and overshot dams, which are designed to permit of flood waters passing over their crests. In the former, the exact and definite strains, at least from outside sources—for there are unknown strains in the dam itself—can be calculated and located, but in the latter, by reason of the varying strains set up by the falling water, the profile cannot be drawn according to any fixed rules. The truth of this is well exemplified by the case of the Gin Gin Weir on the Macquarie River above Warren, which, constructed with the profile of a still water dam, failed as an overshot dam by breaking across, at a depth of about 20 feet from its crest.

Now, it is not the dams which stand, but those which fail, that teach engineers the lessons they are most anxious to learn, and happily failures have been rare, when however they do occur, an inquiry into the cause of their downfall would furnish valuable information. The failure in this case may have been from an inherent weakness in the concrete, or from the design of the profile, or from the lifting power of the water which might have penetrated its face. I do not know, but any information on this important subject will I am sure be appreciated by our engineers.

In the ordinary calculations connected with the design of masonry dams, we assume in the first place that the foundations shall be solid and homogeneous rock, and in the second place that the dam when completed shall be an absolutely rigid structure, we then proceed to carry out the design in connection with the following conditions :—

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It may be stated in mathematical form as follows: The differential equation for dam strains can be made to consist of two parts, viz.

$$\text{Tensional or pressural stress} = p_1 + p_2$$
$$\text{Shearing stress} = S_1 + S_2$$

when p_1 = pressure, as the strain varies, according to its distance from the neutral axis

p_1 = certain additional strains of positive or negative magnitudes

S_1 = the parabolic distribution of stress

S_2 = certain additional stresses of positive or negative magnitude

1. That the horizontal thrust of the water, must be held back by the resistance of the masonry to sliding forward or overturning.

2. That the pressure sustained by the masonry or the foundations must never exceed a certain fixed limit, usually from about 140 to 200 lbs. per square inch.

3. That by causing the resultant of the forces to fall within the middle third of the base, there shall be no tension in any part of the structure.

In a new theory of dam strains recently formulated by Mr. Atcherley and Professor Pearson, both of University College, London, they join issue in many of these points. They say that neither the foundation or the dam can be considered absolutely rigid, that other forces are at work in the body of the dam and in the foundation owing to the elasticity of the materials and other causes besides those of water pressure and weight, that there is tension in the front of the dam, even though the resultant falls within the middle third, and lastly that the stresses in the vertical sections are more critical for stability than those in the horizontal sections. They maintain "that the current treatment of dams is fallacious, for it entirely screens the real source of weakness, viz. in the first place the tension, and in the second place the substantial shear in the vertical sections."

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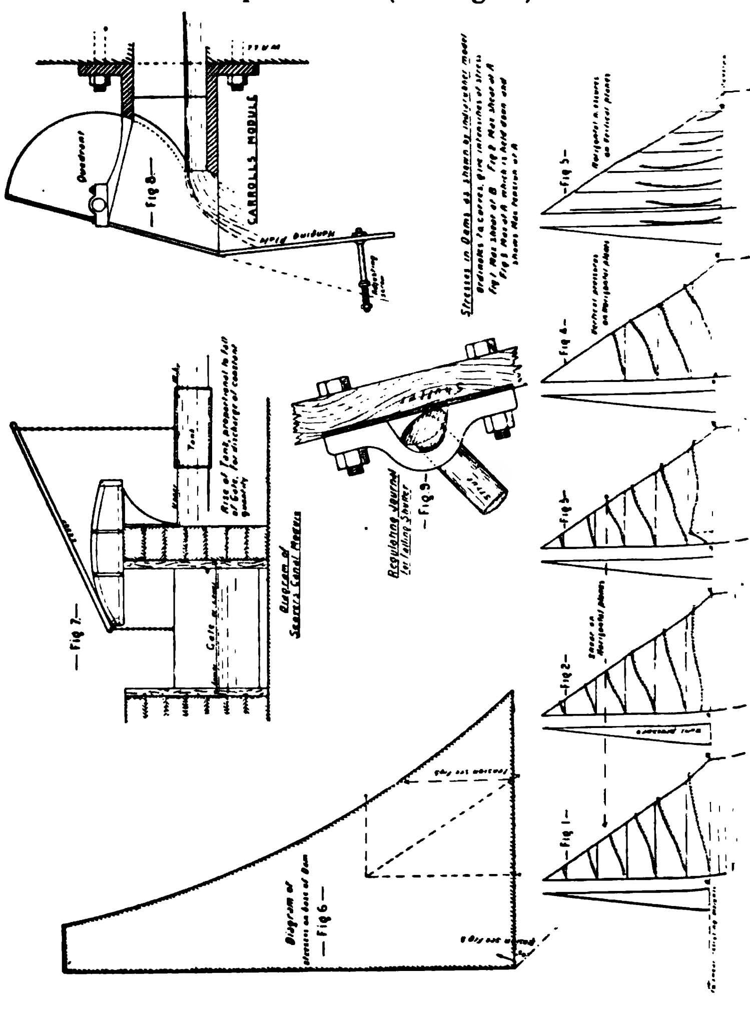
If the height is great compared with the base, p_2 and S_2 ma
be neglected, and the stress is parabolic.

But, says Professor Pearson, p_2 does not $= 0$ as we not know what these internal pressures may be, and if t the parabola or triangle of pressures, we add any system of equilibrated pressures, then the outside pressure remains the same but the internal stresses will be changed. He therefore sums up thus :— (See Fig. 6.)



a. There is the tension at the tail of dams, but it is not f first class importance, because

b. The tension in the substructure is much greater than a the tail, and the substructure, not the dam, is the weakest art.

c. Rupture will take along a line drawn from the tail at .n angle of 45° towards the toe.

d. The shear in the base is neither triangular nor para-ɔolic, but is maximum towards the front of the dam, mini-num towards the centre, with a second maximum towards the toe.

As I understand it, the shearing alluded to may sometimes be rather a crushing by shearing, as when a short stone column fails by sliding taking place along a single plane surface or an angle of about 45° with its sides.

As regards the vertical shearing strains it would seem that the critical section is through the point where the resultant cuts the base, as it is at this point that the dam would tend to overturn, supposing the support of the toe was removed. That is to say, the support afforded by the toe might equally well be afforded by means of a chain attached to the base of the dam at this point and fastened to a point vertically above it. If the face of the dam were lifted it would overturn either by the breaking of this chain, that is by the masonry shearing or by turning over on the toe.

Some very interesting experiments on a dam profile constructed of thick indiarubber, have been carried out by Messrs. Wilson and Gore, which generally prove the statements made by Messrs. Atcherley and Pearson. The rubber was ruled into squares, each of which was strained by means of weights of the correct calculated amounts representing the water pressure, the weights of the dam

sections and the shearing forces along the base. The lines were photographed before and after the weights were applied, and the distortion of the angles in the latter case showed the amounts of the stresses. The total shear resisting weights were equal to the total water resisting weights, but the former could be adjusted so as to give a maximum shear either at the front or at the toe of the dam, and it was found that if the front of the dam was kept down and the maximum shear resisting force applied there, there was a maximum lifting tendency and also a shearing force near the toe.—(Figs. 1 to 5.) The shear along each horizontal section increased gradually towards the toe, but as a vertical section would cut several of these maximum shears, the failure would be more likely to occur in such a section than in a horizontal one. A full account of these experiments is given in *Engineering* for August 4th, 1905.

In this connection it is interesting to note that the length of the vertical section referred to is in Weigmann's Practical profile equal to $\frac{1}{8}$ of the height; in the Furens dam in France, which has its water face curved, $\frac{1}{2}$ of the height; and in the great Perrier dam in India, one of the few in which the curve of the toe is upward, also $\frac{1}{2}$ of the height. So that these two forms of profiles would seem to be the best for the resistance of vertical strains.

A great source of danger in a dam may arise from the porosity of the masonry or concrete, which under a head of say 150 feet, will give rise to an upward hydrostatic pressure of about 65lbs. on the square inch. In some of the more recent German dams provision is made for the free escape of any such water by means of agricultural drain pipes embedded in the concrete which carry it to the back of the dam. It is however along the foundations that such percolation is most likely to take place, as either the joint between the concrete and the rock may be bad,

or else fissures may occur in the latter; and as it is here that tension seems to exist, it is evident that any lifting force must increase the shearing strains in the vertical sections near the toe.

It will be remembered that a diversity of opinion took place as to the necessity or otherwise for cutting a gullet along the foundations of the Cataract dam, which, when filled with a tongue of concrete, would stop any possible percolation, and it may be of interest to point out what has been done in this respect in the case of two recent American dams. The Boonton dam at Jersey City is 114 feet high, with foundations of shale and sandstone, trenched to sound rock, in which was excavated a gullet 8 feet wide and 15 feet deep, afterwards filled with concrete.

At Wachusset Dam, Boston, there was 30 feet of excavation to schist and granite, which was further excavated for the body of the dam to a further depth of 13 feet, below which was cut a trench 20 feet wide and 14 feet deep to receive the concrete tongue. It would seem therefore, that although in the Cataract dam such a cut off trench might possibly be unnecessary, yet in view of the enormous interests involved, not the slightest risk should be taken.

When concrete is used in the construction of storage dams, it should not be rammed in the ordinary way, with heavy broad faced rammers, as such ramming will only consolidate the top surface to the depth of a few inches. To ensure solid work the mortar should be puddled round each stone by means of blunt spades or other similar tools, so as to leave no cavities. In the construction of the Boonton dam light rammers were used to "joggle" the stones to ensure the concrete flowing into all the cracks and crevices, and at the Bhatgarh Dam it was specified that the concrete was to be carefully worked up with stakes.

In the ordinary specifications for concrete, the measured amounts of the materials are stated, but it may happen in some cases that the quantity of mortar is not sufficient to fill the voids in the aggregate. This subject is thoroughly discussed by Lieut. Sankey, R.E., in *Engineering* for September last; he proposes the following as a specification for concrete:—"The percentage of voids in the selected aggregate is to be found, and sand and cement are to be added to make sufficient cement mortar of the quality : sand to 1 cement to fill the voids + 20%."

One point to which I should like to draw special attention is that of the grading of sand for concrete purposes; this is already done in the manufacture of concrete pipes, some of which, with sides only $1\frac{3}{8}$ inch thick, will permit of no leakage under a head of 140 feet. From experiments made by Trautwine it appears that ordinary pure sand from the sea shore weighed 97lbs. per cubic foot, and its voids were 0·41 of the whole. Some very fine sand weighed 82lbs. per cubic foot, and the voids amounted to 0·5 of the mass. From the above we learn that coarse grained sand should be used for making concrete, if however, we mix both together, the voids disappear and the weight increases, from which it follows that the amount of cement can be reduced.

Some interesting experiments were made as to sand grading in concrete by F. Latham, M. Inst. C.E., during the last year, and were referred to by him in a paper read before the Society of Engineers in London. These tests were made in connection with the Penzance sea wall and from the materials used ten briquettes were made. In some cases, the materials were carefully measured according to the stereotyped specifications 1 of cement to 1 of sand &c., and in others care and judgment were used placing a little finer sand to the mixture and a larger pro-

portion of sand to fill up the voids in the gravel, and briquettes made of 1 of cement to 7 of aggregate. The result was that the 1 to 7 briquette stood 115lbs tensile strain and the stereotyped mixing of 1 to 4 but 45lbs. after 21 days immersion in water in each case. It was also noted that there was an appearance of excess of cement showing on the trowelled surface of the former and insufficient cement in the latter, although the proportions in which the cement was actually used were the reverse.

These large masonry dams, the construction of which has just been discussed, are for the storage of large bodies of water at the heads of our rivers. The necessity for such works may be taken as an axiom, and it is not possible, without them, to carry out irrigation sections on any but the smallest scale.

When however, water has been stored it can only be rendered available for irrigation purposes, either by raising its level and so permitting it to flow over the surface of the ground or by pumping it over the banks of the river. The main diversion weir at the head of a canal system must be a fixed structure of sufficient height to turn the required flow down the cuttings under normal conditions. In cases of low river discharge, when little or no water can be spared, the flow down these cuttings must be controlled by means of regulating gates. Weirs which are to be used in connection with pumping plants may either be fixed or movable, if the former, they must be of such a height that they will raise the water level sufficiently and also conserve a good supply, and at the same time not so high as to prevent a small flow from passing down the river. To fulfil both of these conditions they should be, say 6 feet high, with a movable crest of "drop boards" by means of which its height may be increased by say, 4 feet. A small rise will then fill each storage and pass

on to next, and when it has reached a certain fixed distance, the "drop boards" may be put in and the full depth of water conserved.

In cases, in which it is advisable to have the means of removing the whole structure, and so give a clear waterway, some form of falling gates must be used. The oldest of these weirs, that known as the Bear Trap was first erected by Josiah White in 1818 across the Lehigh River in Pennsylvania, and consisted of two gates, the lower of which acted as a strut for the upper, being raised by admitting water beneath it by means of a valve.

In 1834 weirs formed of long timbers, known as "needles," resting at their lower ends against a sill, and at their upper ends against an iron framework were first erected by M.M. Poireé and Chanoine. This weir was afterwards improved by M. Cameré who substituted for the vertical needles horizontal boards hinged together, and which could be rolled up like a curtain.

The next important invention in connection with these works was that of movable shutters by M. Thènard in 1837. This form of weir, which has been used to a considerable extent in India, consists of two gates close together and hinged to the floor. The upper gate falls up stream and is raised by the force of the water, being held back by chains when it is up, the lower gate is raised and kept in position by means of a strut. This later gate now takes all the water pressure, when the upper gate can be lowered to its first position. This weir was defective, in that the great shock received by the sudden raising of the upper gate, often caused the chains to break, or the floor to be pulled up; to remedy this Lieut. Fernacres made use of an ingenious telescopic strut to be used instead of the holding back chains. As the gate is raised the piston of this strut is pushed into a cylinder, the water in which is forced out

through a small hole, so that the effect of the shock is lost and the gate comes to rest quickly.

An altogether new style of movable weir, and the best in use at the present time, was introduced in 1852 by M. Chanoine. This gate consists of a shutter turning on a horizontal axis, forming the top of a trestle, which is hinged to the floor; a strut hinged to the same axis supports the gate when raised. The bottom of this strut rests in a cast iron shoe out of which it can be pulled, when it is necessary to lower the gate horizontally on the floor. A weir of this description has been in use for some years across the Darling river at Bourke, where however the cumbersome "tripping bar" by means of which in the French weirs, the strut was pulled out of the shoe is replaced by a simple device, by means of which the raising and the lowering of the shutters are both effected in a very simple manner. When a shutter is to be raised it is pulled forward till the strut falls into the shoe, and if it is to be lowered the gate is pulled a little more forward, dragging the end of the strut up an inclined plane which is cut away at an angle of 45° in plan, so that when the strut falls over its top it has nothing to support it and so slides down a guide with the shutter folding over it.

One great defect in the action of these weirs is that often when the shutters have tipped over, they will not right themselves till the water level has fallen very much, and so reduced the storage capacity by a large extent. In the case of partly fixed weirs, this difficulty was overcome by M. Chaubart when he designed his self regulating gate. This gate, instead of turning on a trunnion joint, is supported by a pair of sectors which roll on horizontal planes, chains or links being used to keep them in position. As the shutter becomes more and more inclined so does the point of support move proportionally upward, so that it is always in equilibrium.

The author has designed a joint, by means of which the above advantage can be secured in connection with gates of the Chanoine type by forming the ends of the upper horizontal axis into sectors upon which the shutter rests, and with which they are kept in contact by means of D straps. Fig. 9.

A great loss of water takes place in storage reservoirs owing to the flood water which has been backed up by the dam running off to the sill level of the byewash. At the Bhatghar Dam, in India, a series of gates slide in grooves in front of the byewash, and are almost balanced by counterpoises inclosed in chambers left in the masonry. When the water reaches its maximum level it flows by means of pipes into these chambers the outlets of which are smaller than the inlets. The weights of the counterpoises being thus much reduced, the gates fall and allow the excess of stored water to escape. When the level falls below the inlet pipes the water in the chambers escapes, so that the full weight of the counterpoises again coming into play, the gates are raised and the water impounded in the reservoir.

The author has designed a gate which effects the same purpose, but in a different manner, and which requires no chambers in the masonry. This gate is a compound one, consisting of a falling framework hinged to the floor of the byewash, and supporting a bascular gate between its vertical members. A simple tumbling plank hinged to the top of the main gate, when upright, keeps the bascular gate in position by means of a latching gear. The action of this regulating gate is as follows:—When the water rises to the fixed level it turns the top board over, and releases the catch, the bascular gate then swings open, thus taking most of the pressure off the framework, which is held in position by chains passing round wheels at the floor

level and attached to submerged tanks, which now rise and pull the gates down. As the water falls the tanks descend, thus allowing the gates to rise sufficiently to be forced upward by the outward rush of water.

When the irrigation farm is situated close to the river bank the water must be raised by pumping, and to effect this either steam, wind, or water power may be employed. Up to the present time, in this State, the steam engine is almost extensively used for this purpose.

The following is an example of an ordinary plant which irrigates 400 acres by means of a 15 inch centrifugal pump and an engine, lifting water about 25 feet. The crops irrigated are 300 acres of lucerne and 100 acres of cereals, watering taking place about 180 days in the year to a total depth of 24 inches. The expenses of the whole scheme are as follows:—

Cost of engine, boiler, pumps, etc. £1,700	interest	£200
„ laying out the land ... £300		
„ firewood 1 cord @ 5/- per day	... ...	45
„ engine driver @ 9/- „	... ...	81
„ oil @ 2/- per day	... ...	18
„ man irrigating @ 6/- per day...	... ...	54
Total yearly cost	... ...	£398

or say £1 per acre.

Sir S. McCaughey gives the total cost at 4/- to 4/6 per acre per watering, which with 5 waterings comes to about the same figure.

In America of recent years windmills have been largely used for irrigation, and owing to improvements in their construction and increase of sail area, they are proving very valuable machines for the purpose, and in that country a windmill is almost as common an object on a farm as a barn or the house the owner resides in. In this State

Power might also be obtained by running water from the river, down deep wells to the tertiary drifts for the purpose of working turbines, whose power when transformed into electrical energy could be used for pumping river water for irrigation purposes. The horse power developed will $= \cdot 079\, Q\, h$, where Q is the quantity of water in cube feet per second, and h is the fall in feet, so that if only one cubic foot per second is taken from the river and allowed to actuate a turbine at a depth of 120 feet, it will generate almost 10 HP. This power after making all due allowance for loss in conversion, will raise say 4 cubic feet per second or 1,500 gallons per minute to a height of 20 feet. The dynamo is to be worked direct by the turbine at the bottom of the well and the power conveyed by wires to the river bank.

When water has been stored it should be delivered to the consumers in measured quantities and with as little loss as possible. The measurement may be made in two ways, either by the use of meters or modules, the first of which indicates how much has been used, whilst the second only permits of a certain fixed quantity per minute to pass through it. Meters are well known under the following names:—Low pressure positive, in which all the pressure in the pipes is lost, and the quantity of water passing through them is actually measured. Inferential, in which the amount of water is inferred from the velocity of its flow, this velocity being measured by means of vanes. Venturi meters, in which the velocity of the water is shown by means of the height of water in a gauge. This is one of the best form of meters for measuring large quantities of water, as it has no working parts, and consequently no friction. The principle upon which it works, was discovered in 1797 by M. Venturi, who found that the flow of water in a pipe, past its junction with another pipe, created

a vacuum in the latter in which the water rose as the velocity increased.

For irrigation purposes it is however more convenient to have some means by which a fixed quantity of water can be delivered per minute, and to effect this object when the head varies, many forms of modules have been used but so far with but little success. The only one that at all meets these requirements at present was designed by Mr. A. D. Foot, C.E., whereby the head over the outlet orifice can be maintained with some degree of certainty by means of a long returning weir. A very simple and efficient form of module was designed in India many years ago by Lieut. Carroll, of which the following is a short description. Fig. 8. The mouth of the outlet pipe has a plate hanging in front of it, to which is attached a quadrant which more or less closes the waterway. At its highest position there is a free get-away for the water underneath it and between the lips of the outlet and hanging plate. If the velocity be increased, this plate is forced outwards and the quadrant descending into the tube decreases the flow.

The following is a description of a simple module which has been designed by the author (Fig. 7):—A gate free to slide up and down in front of the outlet is suspended from one end of a lever, the other end of which is attached to a tank floating in the main channel. To adjust this apparatus, close the gate down till the required discharge takes place under any given head. Then keeping the chains from the gate and tank stretched upwards, mark upon a board the position of the lever. Repeat this, with various heads, when a series of lines will be drawn on the board, marking the positions of the lever, draw a curve to which these lines form tangents, and cut the board along it. If now the lever rolls on this curve, the relation between the head of water and the size of the outlet must always be such that the discharge will be a constant quantity.

Water being stored and raised, it becomes necessary so to lay out and construct the distributing channels that the largest possible proportion of it shall be delivered on the land it is proposed to irrigate. The loss to the Victorian Irrigation Trusts from this cause is very great, amounting in many cases to between 40 and 50% of the total quantity raised. The experience of many of the Victorian irrigationists is that if their properties had been properly prepared and levelled, two or three times the area they now work could have been irrigated with the same amount of water. In fact the testimony of all the persons who irrigate land goes to prove that money is well expended upon the preliminary work in connection with designs and levels.

The gradients of the drains must be such that on the one hand no scouring out will take place, and on the other that no silting up of the channels will be caused. As to the cross sections, that of a semi-hexagon will give the maximum discharge, but the banks will have too steep a slope. A better form is to make the bottom and sides tangents to a semi-circle, when the top width will in all cases be equal to the sum of the slopes. The great loss due to evaporation may often be reduced by altering the sections of the drains, but in porous ground some protective measures must be taken.

At Mildura, lime concrete has been laid along the main channels and laterals, to the thickness of 3 inches in the former and 2 inches in the latter. The proportions used were 4 of broken stone, and 1 of slaked lime, and the cost was for the 3 inch 1/8 per square yard, and for the 2 inch 1/1½ per square yard. It has stood fairly well, but cracks do occur in it which permit of a certain amount of leakage. An improvement on this, though of course it would be more expensive, would be to have marsupial netting embedded in concrete 3 inches thick, such as I have used

as a protection to canal banks close to the scour caused by a regulating gate, where it showed no signs of leaking.

Tarred cloth has been used in America where it was found that with 12 oz. duck there was no seepage, even under conditions in which the banks would otherwise seep out as through a sieve. Good results may also be obtained by carting clay or silt into the head of the channel, and keeping it well stirred up till it forms a film over the bottom and sides.

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FOR

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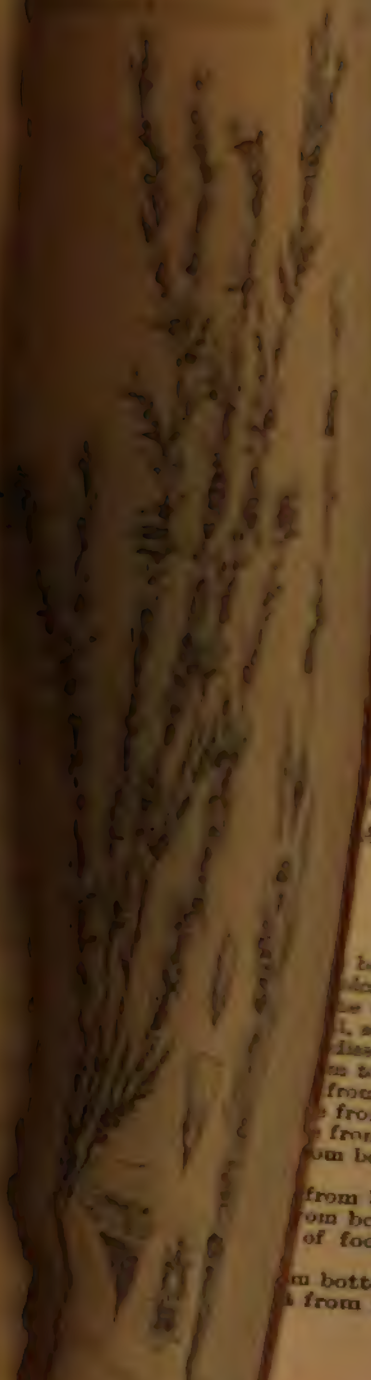
ERRATA.

Page 130, line 8 from bottom, for "The Canoblas have resulted from the building up of volcanic material upon the partly dissected Lithgow plain," read "The Canoblas have resulted from the building up of volcanic material, some part of which, at least, has been deposited upon the partly dissected Lithgow plain."
Page 132, line 14 from top, 8 feet should read 2 feet.
Page 155, sixth line from top, for 0·60, read 0·06.
Page 155, eighth line from top, for CaO, read CoO.
Page 155, fourth line from bottom, for 100·68, read 100·14.
Page XLVI., line 9 from bottom, for "of the Murray," read "of the waters of the Murray."
Page XLVII., line 18 from bottom, for "7256," read "7305."
Page LIII., line 18 from bottom, for "Mr." read "Dr."
Page LIV., last line of footnote, for "River Resources," read "Mineral Resources."
Page LV., line 2 from bottom, (Map showing rainfall lines not printed).
Page LXXIX., line 14 from top, for "two," read "five."



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Royal Society of New South Wales.

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* (Succeeded by F. B. GUTHRIE, F.I.C., F.C.S., from 27 June, 1906.)

Members of Council:

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T. H. HOUGHTON, M. Inst. C.E.	H. D. WALSH, B.E., M. Inst. C.E.

Assistant Secretary:

W. H. WEBB.

FORM OF BEQUEST.

I bequeath the sum of £   to the ROYAL SOCIETY OF NEW SOUTH WALES, Incorporated by Act of the Parliament of New South Wales in 1881, and I declare that the receipt of the Treasurer for the time being of the said Corporation shall be an effectual discharge for the said Bequest, which I direct to be paid within   calendar months after my decease, without any reduction whatsoever, whether on account of Legacy Duty thereon or otherwise, out of such part of my estate as may be lawfully applied for that purpose.

[*Those persons who feel disposed to benefit the Royal Society of New South Wales by Legacies, are recommended to instruct their Solicitors to adopt the above Form of Bequest.*]

NOTICE.

Members are particularly requested to communicate any change of address to the Hon. Secretaries, for which purpose this slip is inserted.

Corrected Address:

Name..

....

Titles, &c..

....

Address...

....

....

Date..........................

To the
Hon. Secretaries,
The Royal Society of N. S. Wales,
5 Elizabeth Street, Sydney.

LIST OF THE MEMBERS

OF THE

Royal Society of New South Wales.

P Members who have contributed papers which have been published in the Society's Transactions or Journal; papers published in the Transactions of the Philosophical Society are also included. The numerals indicate the number of such contributions.

‡ Life Members.

Elected.		
1877	P 5	Abbott, W. E., 'Abbotsford, Wingen.
1895		Adams, J. H. M., Broughton Cottage, St. James' Rd., Waverley.
1904		Adams, William John, M. I. Mech. E., 163 Clarence-street.
1906		Adams, Walter E., Assistant Engineer, Sydney Harbour Trust, Circular Quay.
1890	P 2	Allan, Percy, M. Inst. C.E., Assoc. Am. Soc. C.E., Public Works Department, Sydney.
1898		Alexander, Frank Lee, c/o Messrs. Goodlet and Smith Ld., Cement Works, Granville.
1905		Anderson, Charles, M.A., B.Sc., *Edin.*, 'Waratah,' Lower Ocean-street, Double Bay.
1903		Arnot, Arthur James, Assoc. M. Inst. C.E., M. I. Mech. E., M.I.E.E., Electrical Engineer, 83 Pitt-street.
1902		Arnott, John M., 'Strathfield,' Strathfield.
1899	P 1	Atkinson, A. A., Chief Inspector of Collieries, Department of Mines, Sydney.
1878		Backhouse, Alfred P., M.A., District Court Judge, 'Melita,' Elizabeth Bay.
1894	P 11	Baker, Richard Thomas, F.L.S., Curator, Technological Museum.
1900		Bale, Ernest, C.E., Rockhampton.
1894		‡Balsille, George, 'Lauderdale,' N.E. Valley, Dunedin, N.Z.
1896		Barff, H. E., M.A., Registrar, Sydney University.
1895	P 9	Barraclough, S. Henry, B.E., M.M.E., Assoc. M. Inst. C.E., M. I. Mech. E., Memb. Soc. Promotion Eng. Education; Memb. Internat. Assoc. Testing Materials; Lecturer in Mechanical Engineering, Sydney University; p.r. 'Marmion,' Victoria-street, Lewisham.
1906		Basnett, Nathaniel James, Accountant, 'Loorose,' Punch-st., Mosman.
1894		Baxter, William Howe, Chief Surveyor, Existing Lines Office, Railway Department, Bridge-street.
1877		Belfield, Algernon H., 'Eversleigh,' Dumaresq.
1876		Benbow, Clement A., 48 College-street.
1900		Bender, Ferdinand, Accountant and Auditor, 21 Elizabeth-street, North.
1905		Bignold, Hugh Baron, Barrister-at-Law, Chambers, Wentworth Court, 64 Elizabeth-street.
1906		Binnie, Herbert, 524 Kent-st.; p.r. 'Seabright,' Woollahra Pt.

Elected		
1901		Birks, Lawrence, B. Sc., Assoc. M. Inst. C.E., A.M.I.C.E., F.G.S., City Electrical Engineer, Christchurch, New Zealand.
1905		Blakemore, George Henry, General Manager, Great Cobar Limited, Lithgow.
1888		‡Blaxland, Walter, F.R.C.S. *Eng.*, L.R.C.P. *Lond.*, Fremantle, West Australia.
1893		Blomfield, Charles E., B.C.E. *Melb.*, 'Woombi,' Kangaroo Camp, Guyra.
1898		Blunno, Michele, Licentiate in Science (Rome), Government Viticultural Expert, Department of Agriculture, Sydney.
1905		Board, Peter, M.A. *Syd.*, Under Secretary and Director of Education, Department of Public Instruction, Sydney.
1879		‡Bond, Albert, 131 Bell's Chambers, Pitt-street.
1904		Bosch, Ernest, Consulting Optician, Mutual Life Building, Martin Place.
1891		Bowman, Archer S., B.E., 'Keadue,' Elizabeth Bay Road.
1893		Bowman, John, Assoc. M. Inst. C.E., c/o T. A. Kemmis, Esq., 163 Phillip-street.
1876		Brady, Andrew John, Lic. K. & Q. Coll. Phys. *Irel.*, Lic. R. Coll. Sur. *Irel.*, 3 Lyons Terrace, Hyde Park.
1891		Brennand, Henry J. W., B.A., M.B., Ch. M. *Syd.*, F.R.A.S., F.G.S., 231 Macquarie-street.
1902		Brereton, Victor Le Gay, Solicitor, Royal Chambers, Hunter-street; p.r. 'Osgathorpe,' Gladesville.
1878		‡Brooks, Joseph, F.R.A.S., F.R.G.S., 'Hope Bank,' Nelson-street, Woollahra.
1876		Brown, Henry Joseph, Solicitor, Newcastle.
1906		Brown, James B., Resident Master, Technical School, Granville; p.r. 'Kingston,' Merrylands.
1903		Bruck, Ludwig, Medical Publisher, 15 Castlereagh-street.
1898		‡Burfitt, W. Fitzmaurice, B.A., B. Sc., M.B., Ch. M. *Syd.*, 311 Glebe Road, Glebe Point.
1890		Burne, Dr. Alfred, Dentist, 1 Lyons Terrace, Liverpool street.
1880		Bush, Thomas James, M. Inst. C.E., Australian Gas-Light Company, 153 Kent-street.
1904		Cambage, Richard Hind, F.L.S., Chief Mining Surveyor, Park Road, Burwood.
1904		Cameron, John Mindoro, Assoc. M. Inst. C.E., Public Works, Dept.
1900		Canty, M., 'Rosemont,' 13 York-street, Wynyard Square.
1876		Cape, Alfred J., M.A. *Syd.*, 'Karoola,' Edgecliffe Rd., Edgecliffe.
1897	P 3	Cardew, John Haydon, Assoc. M. Inst. C.E., L.S., 75 Pitt-street.
1901		Card, George William, A.R.S.M., F.G.S., Curator and Mineralogist to the Geological Survey, N.S.W., Department of Mines.
1891		Carment, David, F.I.A. *Grt. Brit. & Irel.*, F.F.A. *Scot.*, Australian Mutual Provident Society, 87 Pitt-st. *Hon. Treasurer.*
1903		Carslaw, H. S., M.A., D. Sc., Professor of Mathematics, Sydney University, Glebe.
1879	P 1	‡Chard, J. S., Licensed Surveyor, Armidale.
1885		Chisholm, William, M.D. *Lond.*, 139 Macquarie-street, North.
1896	P 2	Cook, W. E., M.C.E. *Melb.*, M. Inst. C.E., Water and Sewerage Board, North Sydney.

Elected		
1904		Cooksey, Thomas, PH. D., B. Sc. *Lond.*, F.I.C., Second Government Analyst; p.r. 'Clissold,' Calypso Avenue, Mosman.
1903		Cooper, David John, M.A., 'Grasmere,' 151 Stanmore Road, Stanmore.
1876		Codrington, John Frederick, M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, L.R.C.P. *Edin.*. 'Wynwood,' Wahroonga.
1906		Colley, David John K., Superintendent Royal Mint, Sydney.
1876		Colyer, J. U. C., 'Malvern,' Collingwood and Seymour-streets, Drummoyne.
1882		Cornwell, Samuel, Australian Brewery, Bourke-st., Waterloo.
1892	P 1	Cowdery, George R., Assoc. M. Inst. C.E., 'Glencoe,' Torrington Road, Strathfield.
1886		Crago, W. H., M.R.C.S. *Eng.*, L.R.C.P. *Lond.*, 16 College-street, Hyde Park.
1905		Dampney, Gerald F., Fellow of the Society of Chemical Industry, 'Doonbah,' Hunter's Hill.
1875		Dangar, Fred. H., c/o Messrs. Dangar, Gedye, & Co., Mercantile Bank Chambers, Margaret-street.
1890		Dare, Henry Harvey, M.E., Assoc. M. Inst. C.E., Public Works Department.
1876	P 3	Darley, Cecil West, M. Inst. C.E., Australian Club, Sydney.
1877		Darley, The Right Hon. Sir Frederick, P.C., G.C.M.G., B.A., Chief Justice, Supreme Court.
1886	P 18	David, T.W. Edgeworth, B.A., F.G.S., F.R.S., Professor of Geology and Physical Geography, Sydney University, Glebe.
1892	P 1	Davis, Joseph, M. Inst. C.E., Under Secretary, Department of Public Works.
1885	P 2	Deane, Henry, M.A., M. Inst. C.E., Equitable Building, George-st.; p.r. 'Blanerne,' Wybalena Road, Hunter's Hill.
1877		Deck, John Feild, M.D. Univ. *St. Andrews*, L.R.C.P. *Lond.*, M R.C.S. *Eng.*, 203 Macquarie-st.; p.r. 92 Elizabeth-st., Ashfield.
1899	P 1	De Coque, J. V., c/o Messrs. Gibbs, Bright & Co., 37 Pitt-st.
1894		Dick, James Adam, B.A. *Syd.*, M.B., C.M. *Edin.*, 'Catfoss,' Belmore Road, Randwick.
1875	P 12	Dixon, W. A., F.C.S., Fellow of the Institute of Chemistry of Great Britain and Ireland, 97 Pitt-street.
1880		Dixson, Thomas Storie, M.B. *Edin.*, Mast. Surg. *Edin.*, 151 Macquarie-street
1906		Dixson, William, 'Abergeldie,' Summer Hill.
1876		Docker, Ernest B., M.A. *Syd.*, District Court Judge, 'Eltham,' Edgecliffe Road.
1899		Duckworth, A., F.R.E.S., A.M.P. Society, 87 Pitt-st.; p.r. 'Trentham,' Woollahra.
1873		Du Faur, E., F.R.G.S., 'Flowton,' Turramurra.
1906		Epps, William, Secretary, Royal Prince Alfred Hospital, Camperdown, Sydney.
1879	P 4	Etheridge, Robert, Junr., J.P., Curator, Australian Museum; p.r. 'Inglewood,' Colo Vale,' N.S.W.

Elected		
1876		Evans, George, Fitz Evan Chambers, Castlereagh-street.
1904		Evans, James W., Chief Inspector, Weights and Measures; p.r. 'Glenthorne,' 4 Railway-street, Petersham.
1877		‡Fairfax, Edward Ross, *S. M. Herald* Office, Hunter-street.
1896		Fairfax, Geoffrey E., *S. M. Herald* Office, Hunter-street.
1868		Fairfax, Sir James R., Knt., *S. M. Herald* Office, Hunter-st.
1887		Faithfull, R. L., M.D., *New York* (Coll. Phys. & Surg.), L.R.C.P. L.S.A. *Lond.*, 18 Wylde-street.
1902		Faithfull, William Percy, Barrister-at-Law, Australian Club.
1881		Fiaschi, Thos., M.D., M.Ch. *Pisa*, 149 Macquarie-street.
1888		Fitzhardinge, Grantly Hyde, M.A. *Syd.*, District Court Judge, 'Red Hill,' Beecroft, Northern Line.
1900		‡Flashman, James Froude, M.D. *Syd.*, Jersey Road, Burwood.
		Fleming, Edward G., A.M.I.E.E., 16 O'Connell-street.
1879		‡Foreman, Joseph, M.R.C.S. *Eng.*, L.R C.P. *Edin.*, 141 Macquarie-st.
1881		Foster, The Hon. W. J., K.C., 'Thurnby,' 35 Enmore Road, Newtown.
1905		Foy, Mark, 'Eumemering,' Bellevue Hill, Woollahra.
1904		Fraser, James, M. Inst. C.E., Engineer-in-Chief for Existing Lines, Bridge-street; p.r. 'Arnprior,' Neutral Bay.
1899		French, J. Russell, General Manager, Bank of New South Wales, George-street.
1881		Furber, T. F., F.R.A.S., 'Wavertree,' Kurraba Road, Neutral Bay.
1899		Garran, R. R., M.A., C.M.G., Commonwealth Offices, Spring-st., Melbourne.
1876		George, W. R., 318 George-street.
1879		Gerard, Francis, 'The Grange,' Monteagle, near Young.
1859		Goodlet, J. H., 'Canterbury House,' Ashfield.
1906		Gosche, Vesey Richard, Consul for Nicaragua, 15 Grosvenor-st.
1906		Gosche, W. A. Hamilton, Electrical Engineer, 40 – 42 Clarence-street.
1897		Gould, Major The Hon. Albert John, Senator, 'Eynesbury,' Edgecliffe.
1891	P 1	Grimshaw, James Walter, M. Inst. C.E., M. I. Mech. E., &c. c/o W. Tarleton, 98 Pitt-street.
1899	P 2	Gummow, Frank M., M.C.E., Vickery's Chambers, 82 Pitt-st.
1891	P 11	Guthrie, Frederick B., F.I.C., F.C.S., Chemist, Department of Agriculture, 136 George-street, Sydney. *Hon. Secretary.*
1880	P 2	Halligan, Gerald H., F.G.S., 'Riversleigh,' Hunter's Hill.
1899		Halloran, Aubrey, B.A., LL.B., Savings Bank Chambers, Moore-street.

Elected		
1892		Halloran, Henry Ferdinand, L.S., 82 Pitt-street.
1887	P 7	Hamlet, William M., F.I.C., F.C.S., Member of the Society of Public Analysts; Government Analyst, Health Department, Macquarie-street, North.
1905	P 1	Harker, George, D.Sc., 35 Boulevarde, Petersham.
1881		‡Harris, John, 'Bulwarra,' Jones-street, Ultimo.
1887	P 19	‡Hargrave, Lawrence, Wunulla Road, Woollahra Point.
1884	P 1	Haswell, William Aitcheson, M.A., D.Sc., F.R.S., Professor of Zoology and Comparative Anatomy, University, Sydney; p.r. 'Mimihau,' Woollahra Point.
1900		Hawkins, W. E., Solicitor, 88 Piti-street.
1890	P 2	Haycroft, James Isaac, M.E. Queen's Univ. *Irel.*, M. Inst. C.E. I., Assoc. M. Can. Soc. C.E., Assoc. M. Am. Soc. C.E., L.S., 'The Grove,' off Queen-street, Woollahra.
1891	P 1	Hedley, Charles, F.L.S., Assistant in Zoology, Australian Museum, Sydney.
1900	P 3	Helms, Richard, Experimentalist, Department of Agriculture.
1906		Henning, Edmund Tregenna, B.E. *Syd.*, 'Passy,' Hunter's Hill.
1899		Henderson, J., F.R.E.S., Manager, City Bank of Sydney, Pitt-st.
1899		Henderson, S., M.A., Assoc. M. Inst. C.E., Equitable Building, George-street.
1884	P 1	Henson, Joshua B., Assoc. M. Inst. C.E., Hunter District Water Supply and Sewerage Board, Newcastle.
1905		Hill, John Whitmore, Architect, 'Willamere,' May's Hill, Parramatta.
1876	P 2	Hirst, George D., F.R.A.S., 379 George-street.
1896		Hinder, Henry Critchley, M.B., C.M. *Syd.*, Elizabeth-st., Ashfield.
1892		Hodgson, Charles George, 157 Macquarie-street.
1906		Hodgson, Ralph Vivian, Barrister-at-Law, Wentworth Court, Elizabeth-st.; p.r. 'Tower Cottage,' Old South Head Road.
1901		Holt, Thomas S., 'Sutherland House,' Sylvania.
1904		Holt, Rev. William John, M.A., St. Marys.
1905		Hooper, George, Registrar, Sydney Technical College; p.r. 'Branksome,, Henson-street, Summer Hill.
1905		Hoskins, George J., M. I. Mech. E., Burwood Road, Burwood.
1891	P 2	Houghton, Thos. Harry, M. Inst. C.E., M. I. Mech. E., 63 Pitt.street.
1906		Howle, Walter Creswell, Medical Practitioner, Pambula, N.S.W.
1894	P 2	Hunt, Henry A., F. R. Met. Soc., Commonwealth Meteorologist, Melbourne.
1905		Hyde, Ellis, Analyst, 27 York-street.
1904		Jaquet, John Blockley, A.R.S.M., F.G.S., Acting Chief Inspector of Mines, Geological Surveyor, Department of Mines.
1903		Jenkinson, Edward H., M. I. Mech. E., 15 Macquarie Place.
1904		Jenkins, R. J. H., Fisheries Commissioner, 'Pyalla,' 13A Selwyn-street. Moore Park.
1905	P 2	Jensen, Harold Ingemann, B.Sc., Macleay Fellow of the Linnean Society of New South Wales, Sydney University.
1902		Jones, Henry L., Assoc. Am. Soc. C.E., 14 Martin Place.
1884		‡Jones, Llewellyn Charles Russell, Solicitor, Falmouth Chambers, 117 Pitt-street.
1867		Jones, Sir P. Sydney, Knt., M.D. *Lond.*, F.R.C.S. *Eng.*, 16 College street, Hyde Park; p.r. 'Llandilo,' Boulevard, Strathfield.

Elected		
1876	P 2	Josephson, J. Percy, Assoc. M. Inst. C.E., Stephen Court, 81 Elizabeth-street; p.r. 'Moppity,' George-street, Dulwich Hill.
1878		Joubert, Numa, 'Terranora,' Chinderah, Tweed River.
1883		Kater, The Hon. H. E., J.P., M.L.C., Australian Club.
1878		Keele, Thomas William, M. Inst. C.E., President, Metropolitan Board of Water Supply and Sewerage, 341 Pitt-street.
1906		Keenan, Rev. Bernard, D.D. etc., 'Royston,' Rose Bay.
1887		Kent, Harry C., M.A., F.R.I.B.A., Bell's Chambers, 129 Pitt-st.
1908	P 1	Kennedy, Thomas, Assoc. M. Inst C.E., Public Works, Department.
1901		Kidd, Hector, M. Inst. C.E., M. I. Mech. E., 'Craig Lea,' 15 Mansfield-street, Glebe Point.
1891		King, Christopher Watkins, Assoc. M. Inst. C.E., L.S., Public Works Department, Newcastle.
1896		King, Kelso, 120 Pitt-street.
1892		Kirkcaldie, David, Commissioner, New South Wales Government Railways, Sydney.
1878		Knaggs, Samuel T., M.D. *Aberdeen*, F.R.C.S. *Irel.*, 1 Lyons Terrace, Hyde Park.
1881	P 17	Knibbs, G. H., F.R.A.S., Memb. Internat. Assoc. Testing Materials; Memb. Brit. Sc. Guild; Commonwealth Statistician, Melbourne.
1877		Knox, Edward W., 'Rona,' Bellevue Hill, Double Bay.
1906		Lee, Alfred, Merchant, 'Glen Roona,' Penkivil-st., Bondi.
1874	P 3	Lenehan, Henry Alfred, F.R.A.S., Government Astronomer. Sydney Observatory. *Vice President.*
1901		Lindeman, Charles F., Wine Merchant, Jersey Rd., Strathfield.
1883		Lingen, J. T., M.A. *Cantab.*, 167 Phillip-street.
1901		Little, Robert, 'The Hermitage,' Rose Bay.
1872	P 56	Liversidge, Archibald, M.A. *Cantab.*, LL.D., F.R.S., Hon. F.R.S. *Edin.*, Assoc. Roy. Sch. Mines, *Lond.*; F.C.S., F.G.S., F.R.G.S.; Fel. Inst. Chem. of Gt Brit. and Irel.; Hon. Fel. Roy. Historical Soc. *Lond.*; Mem. Phy. Soc. *Lond.*; Mineralogical Society, *Lond.*; Edin. Geol. Soc.; Mineralogical Society, *France*; Corr. Mem. Edin. Geol. Soc.; New York Acad. of Sciences; Roy. Soc., *Tas.*; Roy. Soc., *Queensland*; Senckenberg Institute, *Frankfurt*; Société d' Acclimat., *Mauritius*; Foreign Corr. Indiana Acad. of Sciences; Hon. Mem. Roy. Soc., *Vict*; N. Z. Institute; K. Leop. Carol. Acad., *Halle a/s*; Professor of Chemistry in the University of Sydney, The University, Glebe; p.r. 'The Octagon,' St. Mark's Road, Darling Point.
1906		Loney, Charles Augustus Luxton, M. Am. Soc. Refr. E., Equitable Building, George-st.
1884		MacCormick, Alexander, M.D., C.M. *Edin.*, M.R.C.S. *Eng.*, 185 Macquarie-street, North.
1887		MacCulloch, Stanhope H., M.B., C.M. *Edin.*, 24 College-street.

Elected		
1892		McDonagh, John M., B.A., M D., M.R.C.P. *Lond.*, F.R.C.S. *Irel.*, 173 Macquarie-street, North.
1897		MacDonald, C. A., C.E., 63 Pitt-street.
1878		MacDonald, Ebenezer, J.P., c/o Perpetual Trustee Co. Ld., 2 Spring-street.
1868		MacDonnell, William J., F.R.A.S., 4 Falmouth Chambers, 117 Pitt-street.
1903		McDonald, Robert, J.P., Acting Under Secretary for Lands; p.r. 'Wairoa,' Holt-street, Double Bay.
1891		McDouall, Herbert Crichton, M.R.C.S. *Eng.*, L.R.C.P. *Lond*, D.P.H. *Cantab.*, Hospital for Insane, Gladesville.
1904		MacFarlane, Edward, J.P., Under Secretary for Lands, Chief Surveyor of the State, N.S.W.; Chairman Local Government Advisory Board; F.R.A.S., Mem. Inst. Surv. N.S.W.; 'St. Julians,' Wycombe and Karraba Roads, Neutral Bay.
1906		McIntosh, Arthur Marshall, Dentist, 'Glen Moid,' Findlay Avenue, Chatswood.
1891	P 2	McKay, R. T., Assoc. M. Inst. C.E., 'Tranquilla,' West-st., North Sydney.
1893		McKay, William J. Stewart, B. Sc., M.B., Ch. M., Cambridge-street, Stanmore.
1876		Mackellar, The Hon. Charles Kinnaird, M.L.C.; M.B., C.M. *Glas.*, Equitable Building, George-street.
1904		McKenzie, Robert, Sanitary Inspector, (Water and Sewerage Board), 'Stonehaven Cottage,' Bronte Road, Waverley.
1880	P 9	McKinney, Hugh Giffin, M. E., Roy. Univ. *Irel.*, M. Inst. C.E., Exchange, 56 Pitt-street; p.r. 'Dilkhusha,' Fuller's Road, Chatswood.
1903		McLaughlin, John, Solicitor, Clement's Chambers, 88 Pitt-st.
1876		MacLaurin, The Hon. Sir Henry Normand, M.L.C., M.A., M.D., L.R.C.S. *Edin.*, LL.D. *St. Andrews*, 155 Macquarie-street.
1901	P 1	McMaster, Colin J., Chief Commissioner of Western Lands; p.r. Wyuna Road, Woollahra Point.
1894		McMillan, Sir William, 'Logan Brae,' Waverley.
1900		MacTaggart, A. H., D.D.S. *Phil.* U.S.A., King and Phillip-sts.
1899		MacTaggart, J. N. C., M.E. *Syd.*, Assoc. M. Inst. C.E., Water and Sewerage Board, 341 Pitt-street.
1882	P 1	Madsen, Hans F., 'Hesselmed House,' Queen-st., Newtown.
1888		Maiden, J. Henry, J.P., F.L.S., Hon. Fellow Roy. Soc., S.A. Hon. Memb. Nat. Hist Soc., W.A.; Netherlands Soc. for Promotion of Industry; Philadelphia Coll. Pharm.; Pharm. Soc. N.S.W.; Brit. Pharm. Conf; Corr. Fellow Therapeutical Soc., Lond.; Corr. Memb. Pharm. Soc. Great Britain; Bot. Soc. Edin.; Soc. Nac. de Agricultura (Chile); Soc. d' Horticulture d' Alger; Union Agricole Calédonienne; Soc. Nat. etc., de Chérbourg; Roy. Soc., Tas.; Inst. Nat. Genévois; Government Botanist and Director, Botanic Gardens, Sydney. *Hon. Secretary.*
1906		Maitland, Louis Duncan, Dental Surgeon, 6 Lyons' Terrace, Liverpool-street.
1880	P 1	Manfred, Edmund C., Montague-street, Goulburn.
1897		Marden, John, B.A., M.A., LL.B. *Melb.*, LL.D. *Syd.*, Principal. Presbyterian Ladies' College, Sydney.

Elected		
1875	P 21	Mathews, Robert Hamilton, L.S., Assoc. Etran. Soc. d' Anthrop. de Paris; Cor. Mem. Anthrop. Soc., Washington, U.S.A.; Cor. Mem. Anthrop. Soc., Vienna; Cor. Mem. Roy. Geog. Soc. Aust.,Queensland; 'Carcuron,' Hassall-st., Parramatta.
1903		Meggitt, Loxley, Manager Co-operative Wholesale Society, Alexandria.
1896	P 7	Merfield, Charles J., F.R.A.S., Mitglied der Astronomischen Gesellschaft, Observatory Sydney.
1905		Miller, James Edward, Barton-st., Cobar,
1887		Miles, George E., L.R.C.P. *Lond.*, M.R.C.S. *Eng.*, The Hospital, Rydalmere, near Parramatta.
1903		Minell, W. Percy, Incorporated Accountant, Martin Chambers, Moore-street.
1889	P 8	Mingaye, John C. H., F.I.C., F.C.S., Assayer and Analyst to the Department of Mines, Government Metallurgical Works, Clyde; p.r. Campbell-street, Parramatta.
1879		Moore, Frederick H., Illawarra Coal Co., Gresham-street.
1877		‡Mullens, Josiah, F.R.G.S., 'Tenilba,' Burwood.
1879		Mullins, John Francis Lane, M.A. *Syd.*, 'Killountan,' Challis Avenue, Pott's Point.
1887		Munro, William John, B.A., M.B., C.M., M.D. *Edin.*, M.R.C.S. *Eng.*, 213 Macquarie-street; p.r. 'Forest House,' 182 Pyrmont Bridge Road, Forest Lodge.
1876		Myles, Charles Henry, 'Dingadee,' Burwood.
1893	P 1	Nangle, James, Architect, 'St. Elmo,' Tupper-st., Marrickville.
1901		Newton, Roland G., B.A. *Syd.*, 'Walcott,' Boyce-st., Glebe-Point.
1891		‡Noble, Edwald George, Public Works Department, Newcastle.
1893		Noyes, Edward, Assoc. Inst. C.E., Assoc. I. Mech. E., c/o Messrs. Noyes Bros., 109 Pitt-street.
1903		Old, Richard, Solicitor, 'Waverton,' Bay Rd., North Sydney.
1896		Onslow, Lt. Col. James William Macarthur, Camden Park, Menangle.
1875		O'Reilly, W. W. J., M.D., M.Ch. Q. Univ. *Irel.*, M.R.C.S. *Eng.*, 197 Liverpool-street, Hyde Park.
1891		Osborn, A. F., Assoc. M. Inst. C.E., Public Works Department, Cowra.
1883		Osborne, Ben. M., J.P., 'Hopewood,' Bowral.
1906		Oschatz, Alfred Leopold, Teacher of Languages, 167 Victoria-street, Potts Point.
1903		Owen, Rev. Edward, B.A., All Saints' Rectory, Hunter's Hill.
1880		Palmer, Joseph, 96 Pitt-st.; p.r. Kenneth-st., Willoughby.
1878		Paterson, Hugh, 197 Liverpool-street, Hyde Park.
1906		Pawley, Charles Lewis, Dentist, 187 Regent-street.
1901		Peake, Algeronon, Assoc. M. Inst. C.E., 25 Prospect Road, Ashfield.
1899		Pearse, W., Union Club; p.r. Moss Vale.

Elected		
1877		Pedley, Perceval R., 227 Macquarie-street.
1899		Peterson, T. Tyndall, Member of Sydney Institute of Public Accountants, Copper Mines, Burraga.
1879	P 6	Pittman, Edward F., Assoc. R. S.M., L.S., Under Secretary and Government Geologist, Department of Mines.
1896		Plummer, John, 'Northwood.' Lane Cove River; Box 413 G.P.O.
		Poate, Frederick, Lands Office, Moree,
1879		Pockley, Thomas F. G., Commercial Bank, Singleton.
1887	P 1	Pollock, James Arthur, B.E. Roy. Univ. *Irel.*, B.Sc. *Syd.*, Professor of Physics, Sydney University.
1896		Pope, Roland James, B. A. *Syd.*, M. D., C.M., F.R.C.S. *Edin.*, Ophthalmic Surgeon, 235 Macquarie-street.
1893		Purser, Cecil, B.A., M.B., Ch. M. *Syd.*, 'Valdemar,' Boulevard, Petersham.
1901	P 1	Purvis, J. G. S., Water and Sewerage Board, 341 Pitt-street.
1876		Quaife, F. H., M.A., M.D., Mast. Surg. *Glas.*, 'Hughenden,' 14 Queen-street, Woollahra. *Vice President.*
1890	P 1	Rae, J. L. C., 'Endcliffe,' Church-street, Newcastle.
1902		Ramsay, Arthur A., Assistant Chemist, Department of Agriculture, 136 George-street.
1904		Ramsay, David, Surveyor, Box 600 G.P.O.
1865	P 1	‡Ramsay, Edward P., LL.D. *St. And.*, F.R.S.E., F.L.S., 8 Palace-street, Petersham.
1890		Rennie, George E., B.A. *Syd.*, M.D. *Lond.*, M.R.C.S. *Eng.*, 159 Macquarie-street.
1906		Redman, Frederick G., 'Honda,' Shell Cove Road, Neutral Bay.
1870		‡Renwick, The Hon. Sir Arthur, Knt., M.L.C., B.A. *Syd.*, M.D., F.R.C.S. *Edin.*, 325 Elizabeth-street.
1902		Richard, G. A., Mount Morgan Gold Mining Co., Mount Morgan, Queensland.
1906		Richardson, H. G. V., Draftsman, Newcastle-street, Rose Bay.
1963	P 2	Rooke, Thomas, Assoc. M. Inst. C.E., Electrical Engineer, Town Hall, Sydney.
1893	P 1	Roberts, W. S. de Lisle, C.E., 'Kenilworth,' Penshurst.
1885		Rolleston, John C., Assoc. M. Inst. C.E., Public Works Department and Australian Club.
1892		Rossbach, William, Assoc. M. Inst. C.E., Public Works Department, Sydney.
1884		Ross, Chisholm, M.D. *Syd.*, M.B., C.M. *Edin.*, 147 Macquarie-st.
1895	P 1	Ross, Herbert E., Equitable Building, George-street.
1904	P 2	Ross, William J. Clunies, B. Sc. *Lond. & Syd.*, F.G.S., Lecturer in Chemistry, Technical College, Sydney.
1882		Rothe, W. H., Colonial Sugar Co., O'Connell-street, and Union Club.
1897		Russell, Harry Ambrose, B.A., Solicitor, c/o Messrs. Sly and Russell, 369 George-street; p.r. 'Mahuru,' Fairfax Road, Bellevue Hill.
1893		Rygate, Philip W., M.A., B.E. *Syd.*, Assoc. M. Inst. C.E., Phœnix Chambers, 158 Pitt-street.

Elected		
1905		Scheidel, August, PH. D., Managing Director, Commonwealth Portland Cement Co., Sydney; Union Club.
1899		Schmidlin, F., 83 Elizabeth-street, Sydney.
1892	P 1	Schofield, James Alexander, F.C.S., A.R.S.M., University, Sydney.
1905		Scott, Ernest Kilburn, Assoc. M. Inst. C.E., M. I. Mech. E., M.I.E.E., Consulting Engineer, and Lecturer in Electricity, The University, Sydney.
1856	P 1	‡Scott, Rev. William, M.A. *Cantab.*, Kurrajong Heights.
1877	P 4	Selfe, Norman, M. Inst. C.E., M. I. Mech. E, Victoria Chambers, 279 George-street.
1904	P 1	Sellors, R. P., B.A. *Syd.*, 'Cairnleith,' Springdale Road, Killara.
1891		Shaw, Percy William, M. Inst. C.E., Australian Smelting Corporation, Dapto.
1883	P 3	Shellshear, Walter, M. Inst. C.E., Inspecting Engineer, Existing Lines Office, Bridge-street.
1905		Simpson, D. C., M. Inst. C.E., N.S. Wales Railways, Redfern; p.r. 'Omapere,' Lane Cove Road, North Sydney.
1900		Simpson, R. C., Technical College, Sydney.
1882		Sinclair, Eric, M.D., C.M. *Glas.*, Inspector-General of Insane, 9 Richmond Terrace, Domain; p.r. Cleveland-street, Wahroonga.
1893		Sinclair, Russell, M. I. Mech. E., etc., Vickery's Chambers, 82 Pitt-st.
1891	P 3	Smail, J. M., M. Inst. C.E., Chief Engineer, Metropolitan Board of Water Supply and Sewerage, 341 Pitt-street.
1904	P 1	Smail, Herbert Stuart Inglis, B.E. *Syd.*, Assoc. M. Inst. C.E., Bagan Serai, Federated Malay States.
1906		Small, Frederick Henry, M. Inst. C.E., 'Rotherwood,' Gordon Rd., Chatswood.
1893	P 33	Smith, Henry G., F.C.S., Assistant Curator, Technological Museum, Sydney.
1874	P 1	‡Smith, John McGarvie, 89 Denison-street, Woollahra.
1899		Smith, R. Greig, D. Sc. *Edin.*, M. Sc. *Dun.*, Macleay Bacteriologist, 'Otterburn,' Double Bay.
1886		Smith, Walter Alexander, M. Inst. C.E., Public Works Department, 12A Phillip-street.
1896		Spencer, Walter, M.D. *Brux.*, 13 Edgeware Road, Enmore.
1904		Stanley, Henry Charles, M. Inst C.E., Royal Chambers, Hunter and Castlereagh-streets.
1892	P 1	Statham, Edwyn Joseph, Assoc. M. Inst. C.E., Cumberland Heights, Parramatta.
1900		Stewart, J. D., M.R.C.V.S., Government Veterinary Surgeon, Department of Mines and Agriculture; p.r. Cowper-street, Randwick.
1903		Stoddart, Rev. A. G., The Rectory, Manly.
1883	P 3	Stuart, T. P. Anderson, M.D., LL.D. *Edin.*, Professor of Physiology, University of Sydney; p.r. 'Lincluden,' Fairfax Road, Double Bay. *President.*
1901	P 2	Süssmilch, C. A., Technical College, Sydney.
1906		Taylor, Allen, 'Ellerslie,' 85 Darlinghurst Road.
1906		Taylor, Horace, Registrar, Dental Board, 7 Richmond Terrace, Domain.
1905		Taylor, John M., M.A., LL.B. *Syd.*, 'Woonona' 43 East Crescent-street, McMahon's Point, North Sydney.

Elected		
1898		‡Taylor, James, B. Sc., A.R.S.M., 'Adderton,' Dundas.
1899		Teece, R., F.I.A., F.F.A., General Manager and Actuary, A.M.P. Society, 87 Pitt-street.
1861	P 19	Tebbutt, John, F.R.A.S., Private Observatory, The Peninsula, Windsor, New South Wales.
1896		Thom, James Campbell, Solicitor, 'Dunoon,' Eurella-street, Burwood.
1896		Thom, John Stuart, Solicitor, Athenæum Chambers, 11 Castlereagh-street.
1878		Thomas, F. J., Newcastle and Hunter River Steamship Co., 147 Sussex-Street.
1879		Thomson, Dugald, M.H.R., 'Wyreepi,' Milson's Point.
1885	P 2	Thompson, John Ashburton, M.D. *Brux.*, D.P.H. *Cantab.*, M.R.C.S. *Eng.*, Health Department, Macquarie-street.
1896		Thompson, Capt. A. J. Onslow, Camden Park, Menangle.
1892		Thow, William, M. Inst. C.E., M. I. Mech. E., Locomotive Department, Eveleigh.
1894		Tidswell, Frank, M.B., M. Ch., D.P.H. *Cantab.*, Health Department, Sydney,
1894		Tooth, Arthur W., Kent Brewery, 26 George-street, West.
1879		Trebeck, P. C., F. R. Met. Soc., 12 O'Connell-street.
1900		Turner, Basil W,, A.R.S.M., F.C.S., Wood's Chambers, Moore-st.
1905		Turner, John William, Superintendent of Technical Education, Technical College, Sydney.
1883		Vause, Arthur John, M.B., C.M. *Edin.*, 'Bay View House,' Tempe.
1884		Verde, Capitaine Felice, Ing. Cav., viâ Fazio 2, Spezia, Italy.
1890		Vicars, James, M.C.E., City Engineer and Surveyor, Adelaide.
1892		Vickery, George B., 78 Pitt-street,
1903	P 1	Vonwiller, Oscar U., B. Sc. Demonstrator in Physics, University of Sydney.
1876		Voss, Houlton H., J.P., Oriental Club; Hanover Square, London.
1904		Vogan, Harold Sebastian, Assoc. M. Inst. C.E., Authorised Surveyor N.Z., Chief Draftsman, Existing Railways N.S.W., Bridge-st.
1906		Wade, James Scargill, Assoc. M. Inst C.E., Public Works Department, Manilla, N.S.W.
1898	P 1	Wade, Leslie, A. B., M. Inst. C.E., Department of Public Works.
1879		Walker, H. O., Commercial Union Assurance Co., Pitt-street.
1899		‡Walker, Senator The Hon. J. T., 'Rosemont,' Ocean-street, Woollahra.
1901		Walkom, A. J., A.M.I.E.E., Electrical Branch, G.P.O., Sydney.
1900		Wallach, Bernhard, B.E. *Syd*,, Electrical Engineer, 'Oakwood,' Wardell Road, Dulwich Hill.
1891	P 1	Walsh, Henry Deane, B.E., T.C. *Dub.*, M. Inst. C.E., Engineer-in-Chief, Harbour Trust, Circular Quay.
1903		Walsh, Fred., George and Wynyard-streets; p.r. 'Walworth,' Park Road, City E.
1901		Walton, R. H., F.C.S., 'Flinders,' Martin's Avenue, Bondi.
1898		Wark, William Assoc. M. Inst C.E., 9 Macquarie Place; p.r. Kurrajong Heights.

Elected		
1877		Warren, William Edward, B.A., M.D., M.Ch., Queen's University *Irel.*, M.D. *Syd.*, 283 Elizabeth-street, Sydney.
1883	P 16	Warren, W. H., Wh. Sc., M. Inst. C.E., Mem. Am. Soc. C.E., Professor of Engineering, University of Sydney. *Vice President.*
1876		Watkins, John Leo, B.A. *Cantab.*, M.A. *Syd.*, Parliamentary Draftsman. Attorney General's Department, Macquarie-st.
1876		Watson, C. Russell, M.R.C.S. *Eng.*, 'Woodbine,' Erskineville Road, Newtown.
1897		Webb, Frederick William, C.M.G., J.P., 'Livadia,' *Manly.*
1903		Webb, A, C. F., M.I.E.E. Vickery's Chambers, 82 Pitt-street.
1892		Webster, James Philip, Assoc. M. Inst. C.E., L.S., *New Zealand*, Town Hall, Sydney.
1867		Weigall, Albert Bythesea, B.A. *Oxon.*, M.A. *Syd.*, Head Master, Sydney Grammar School, College-street.
1902		Welsh, David Arthur, M.D., M.A., B.Sc., Professor of Pathology, Sydney University, Glebe.
1881		‡Wesley, W. H.
1906		Whitehead, Lindsay, Bank of N. S. Wales, George-street.
1892		White, Harold Pogson, F.C.S., Assistant Assayer and Analyst, Department of Mines; p.r. 'Quantox,' Park Road, Auburn.
1877		‡White, Rev. W. Moore, A.M., LL.D., T.C.D.
1879		‡Whitfeld, Lewis, M.A. *Syd.*, 'Glencoe,' Lower Forth-st. Woollahra
1883		Wilkinson, W. Camac, M.D. *Lond.*, M.R.C.P. *Lond.*, M.R.C.S. *Eng.*, 213 Macquarie-street.
1876		Williams, Percy Edward, Comptroller, Government Savings Bank, Sydney.
1901		Willmot, Thomas, J.P., Toongabbie.
1878		Wilshire, James Thompson, F.R.H.S., J.P., 'Coolooli,' Bennet Road, Neutral Bay.
1879		Wilshire, F. R., Police Magistrate, Penrith.
1890		Wilson, James T., M.B., Ch. M., *Edin.*, Professor of Anatomy, University of Sydney.
1891		Wood, Percy Moore, L.R.C.P. *Lond.*, M.R.C.S. *Eng.*, 'Redcliffe,' Liverpool Road, Ashfield.
1906	P 3	Woolnough, Walter George, D.Sc., F.G.S., Demonstrator in Geology, University of Sydney.
1876	P 1	Woolrych, F. B. W., 'Verner,' Grosvenor-street, Croydon.
1902		Wright, John Robinson, Lecturer in Art, Technical College, Harris-street, Sydney.

Honorary Members.

Limited to Thirty.

M.—Recipients of the Clarke Medal.

1901		Baker, Sir Benjamin, K.C.M.G., D.Sc., LL.D., F.R.S., M. Inst. C.E., etc., 2 Queen Square Place, London, S.W.
1875		Bernays, Lewis A., C.M.G., F.L.S., Brisbane.
1905		Cannizzaro, Stanislao. Professor of Chemistry, Reale Università Rome.
1900		Crookes, Sir William, F.R.S., 7 Kensington Park Gardens, London W.
1875	M	Ellery, Robert L. J., F.R.S., F.R.A.S., c/o Government Astronomer of Victoria, Melbourne.
1905		Fischer, Emil, Professor of Chemistry, University, Berlin.

Elected		
1875	P 1 M	Hector, Sir James, K.C.M.G., M.D., F.R.S., late Director of the Colonial Museum and Geological Survey of New Zealand, Wellington, N.Z.
1880	M	Hooker, Sir Joseph Dalton, K.C.S.I., M.D., C.B., F.R.S., &c., c/o Director of the Royal Gardens, Kew.
892		Huggins, Sir William, K.C.B., D.C.L., LL.D., F.R.S., &c., 90 Upper Tulse Hill, London, S.W.
1901		Judd, J. W., C.B., F.R.S., F.G.S., Professor of Geology, Royal College of Science, London.
1903		Kelvin, Right Hon. William Thomson, Lord, O.M., G.C.V.O., D.C.L., LL.D., F.R.S., Hon. M. Inst. C.E., etc., 15 Eaton Place, London, S.W.
1903		Lister, Right Hon. Joseph, Lord, O.M., B.A., M.B., F R.C S. D.C.L., F.R.S., Hon. M. Inst. C.E., etc., 12 Park Crescent, Portland Place, London, W.
1901		Newcomb, Professor Simon, LL.D., Ph. D., For. Mem. R.S. Lond., United States Navy, Washington.
1905		Oliver, Daniel, LL.D., F.R S., Emeritus Professor of Botany, University College, London.
1894		Spencer, W. Baldwin, M.A., C.M G., F.R.S., Professor of Biology, University of Melbourne.
1900	M	Thiselton-Dyer, Sir William Turner, K C.M.G., C.I.E., M.A., B.Sc. F.R.S., F.L.S., late Director, Royal Gardens, Kew.
1895		Wallace, Alfred Russel, D.C.L. *Oxon.*, LL.D. *Dublin*, F.R.S., Old Orchard, Broadstone, Wimborne, Dorset.

OBITUARY 1906-7.

Honorary Member.

1887	Foster, Sir Michael, M.D., F.R.S.

Ordinary Members.

1873	Norton, Hon. James, M.L.C., LL.D.
1864	Russell, H. C., B.A., C.M.G., F.R.S.
1879	Young, John

AWARDS OF THE CLARKE MEDAL.

Established in memory of

THE LATE REVD. W. B. CLARKE, M.A., F.R.S., F.G.S., &c.,

Vice-President from 1866 *to* 1878.

To be awarded from time to time for meritorious contributions to the Geology, Mineralogy, or Natural History of Australia.

1878 Professor Sir Richard Owen, K.C.B., F.R.S., Hampton Court.

1879 George Bentham, C.M.G., F.R.S., The Royal Gardens, Kew.

1880 Professor Thos. Huxley, F.R.S., The Royal School of Mines, London. 4 Marlborough Place, Abbey Road, N.W.

1881 Professor F. M'Coy, F.R.S., F.G.S., The University of Melbourne.

1882 Professor James Dwight Dana, LL.D., Yale College, New Haven, Conn., United States of America.

1883 Baron Ferdinand von Mueller, K.C.M.G., M.D., PH.D., F.R.S., F.L.S. Government Botanist, Melbourne.

1884 Alfred R. C. Selwyn, LL.D., F.R.S., F.G.S., Director of the Geological Survey of Canada, Ottawa.

1885 Sir Joseph Dalton Hooker, K.C.S.I., C.B., M.D., D.C.L., LL.D., &c., late Director of the Royal Gardens, Kew.

1886 Professor L. G. De Koninck, M.D., University of Liège, Belgium.

1887 Sir James Hector, K.C.M.G., M.D., F.R.S., Director of the Geological Survey of New Zealand, Wellington, N.Z.

1888 Rev. Julian E. Tenison-Woods, F.G.S., F.L.S., Sydney.

1889 Robert Lewis John Ellery, F.R.S., F.R.A.S., Government Astronomer of Victoria, Melbourne.

1890 George Bennett, M.D. Univ. *Glas.*, F.R.C.S. *Eng.*, F.L.S., F.Z.S., William Street, Sydney.

1891 Captain Frederick Wollaston Hutton, F.R.S., F.G.S., Curator, Canterbury Museum, Christchurch, New Zealand.

1892 Sir William Turner Thiselton Dyer, K.C.M.G., C.I.E., M.A., B.Sc., F.R.S., F.L.S., Director, Royal Gardens, Kew.

1893 Professor Ralph Tate, F.L.S., F.G.S., University, Adelaide, S.A.

1895 Robert Logan Jack, F.G.S., F.R.G.S., Government Geologist, Brisbane, Queensland.

1895 Robert Etheridge, Junr., Government Palæontologist, Curator of the Australian Museum, Sydney.

1896 Hon. Augustus Charles Gregory, C.M.G., M.L.C., F.R.G.S., Brisbane.

1900 Sir John Murray, Challenger Lodge, Wardie, Edinburgh.

1901 Edward John Eyre, Walreddon Manor, Tavistock, Devon, England.

1902 F. Manson Bailey, F.L.S., Colonial Botanist of Queensland, Brisbane.

1903 Alfred William Howitt, D. Sc. *Cantab.*, F.G.S., Hon. Fellow Anthropol. Inst. of Gt. Brit. and Irel., 'Eastwood,' Bairnsdale, Victoria.

AWARDS OF THE SOCIETY'S MEDAL AND MONEY PRIZE.

The Royal Society of New South Wales offers its Medal and Money Prize for the best communication (provided it be of sufficient merit) containing the results of original research or observation upon various subjects published annually.

Money Prize of £25.

1882 John Fraser, B.A., West Maitland, for paper on 'The Aborigines of New South Wales.'

1882 Andrew Ross, M.D., Molong, for paper on the 'Influence of the Australian climate and pastures upon the growth of wool.'

The Society's Bronze Medal and £25.

1884 W. E. Abbott, Wingen, for paper on 'Water supply in the Interior of New South Wales.'

1886 S. H. Cox, F.G.S., F.C.S., Sydney for paper on 'The Tin deposits of New South Wales.

1887 Jonathan Seaver, F.G.S., Sydney, for paper on 'Origin and mode of occurrence of gold-bearing veins and of the associated Minerals.

1888 Rev. J. E. Tenison-Woods, F.G.S., F.L.S., Sydney, for paper on 'The Anatomy and Life-history of Mollusca peculiar to Australia.'

1889 Thomas Whitelegge, F.R.M.S., Sydney, for 'List of the Marine and Fresh-water Invertebrate Fauna of Port Jackson and Neighbourhood.

1889 Rev. John Mathew, M.A., Coburg, Victoria, for paper on 'The Australian Aborigines.

1891 Rev. J. Milne Curran, F.G.S., Sydney, for paper on 'The Microscopic Structure of Australian Rocks.'

1892 Alexander G. Hamilton, Public School, Mount Kembla, for paper on 'The effect which settlement in Australia has produced upon Indigenous Vegetation.'

1894 J. V. De Coque, Sydney, for paper on the 'Timbers of New South Wales.'

1894 R. H. Mathews, L.S., Parramatta, for paper on 'The Aboriginal Rock Carvings and Paintings in New South Wales.'

1895 C. J. Martin, B.Sc., M.B. *Lond*, Sydney, for paper on 'The physiological action of the venom of the Australian black snake (*Pseudechis porphyriacus*).'

1896 Rev. J. Milne Curran, Sydney, for paper on 'The occurrence of Precious Stones in New South Wales, with a description of the Deposits in which they are found.'

PRESIDENTIAL ADDRESS.

By H. A. LENEHAN, F.R.A.S.,
Acting Government Astronomer.

[*Read before the Royal Society of N. S. Wales, May 2, 1906.*]

ONE more year has been added to the life of our Society, and during its course many events of scientific interest have been recorded in the world's progress in science. In the first place, referring to our own internal affairs, with judicious management, our Treasurer has pulled through the troubles that faced him at the commencement of the session better than we had anticipated, but the necessity for watchful care of our expenditure will be needed for some time, as the Government subsidy has been reduced by one half. The Council did its utmost to alter the decision of the Minister by interviewing him, but to no purpose. One object that should be in each member's mind, is that of encouraging desirable gentlemen to join the Society. Thus our finances would be improved and additional contributions to the business of our general meetings would be offered.

Roll of Members.—The number of members on the Roll on the 30th April, 1905 was 336. During the past year 18 members were elected; the deaths numbered 5, and resignations 14, leaving a total of 335 to date.

Mr. H. C. Russell.—Within the last two years a familiar face has been missed from our monthly meetings in the person of Mr. H. C. Russell, B.A., C.M.G., F.R.S., etc., whose illness in October, 1903, necessitated his taking a holiday from his official duties, and later on of retiring from the public service and giving up his position as Government Astronomer of New South Wales, a position he had held from

the year 1870, having been for the previous twelve years connected with the Observatory. During this long and honourable service he has in his capacity of Councillor and President of this Society contributed many papers, and has many times afforded valuable assistance to the council. On February 28th, 1905, he permanently retired from his duties, and has only on one or two occasions been seen at our meetings since.

Obituary.—The following is a list of members who have died during the year:—

Dean, Alexander,	elected	1878
Hume, J. K.,	„	1877
Keep, John,	„	1877
Moore, Charles,	„	1856
Perkins, Henry A.,	„	1877
Portus, A. B.,	„	1897

"The Father of the Society," being the oldest then living member, was Mr. Charles Moore, the erstwhile Director of the Botanic Gardens; of late years he did not take a very active part in the business of the Society because of infirmities. He was Councillor for many years and a former President; he was always genial and ever ready to give information on botanical and other matters which by his long and active life he was particularly qualified to do; he also contributed interesting papers to the Society.

Honorary Members.—Number on the Roll on the 30th April, 1905, 17; new members elected 3, and lost by death 2, leaving 18 on the Roll at the present time. *Deaths*—The Hon. Sir Augustus Charles Gregory, elected 1875; Capt. Frederick Wollaston Hutton, elected 1888.

Concerning Captain Hutton, F.R.S., Hon. Member of our Society, Professor Liversidge submitted a notice of his demise in these words:—

"The members of the Royal Society of New South Wales learn with the deepest regret of the death of Captain Hutton, F.R.S., one of its Honorary Members, and they hereby place on record their high appreciation of Captain Hutton's great and life long services for the advancement of science. That the above resolution be forwarded to the late Captain Hutton's family with an expression of this Society's deep sympathy with them in their bereavement."

The Philosophical Institute of Canterbury, N.Z., is establishing a fund for original research, as a memorial to Captain Hutton.

Although not a member of our Society, I may mention the name of one of the greatest benefactors of the Sydney University, Sir Peter Nicol Russell, who by his gift of £100,000 founded the school of Engineering. He died on July 10th, 1905, at the age of 89.

Amongst distinguished non-Australian men of science who have passed away during my term of office I may mention Professor Jules Oppert, Professor of Assyrian Philology and Archæology at the Collége de France, renowned for his contributions to astronomical chronology and his works on Chaldea and Assyria.

The death is also announced at 76 years of age of Prof. Franz Reuleaux, who as author of a number of engineering works and Director of the Berlin Industrial Institute, rendered good service to the development of practical and scientific engineering in Germany.

Mr. C. T. Yerkes, whose death was announced on 30th December, 1905, came into prominence over proposals for vast schemes of electric railways in London in 1903. Previously he had been connected with street railways in Philadelphia and Chicago. He presented the finest telescope in the world to the observatory called after his name

at Lake Geneva, Wisconsin, U.S.A., and had the satisfaction during his life of seeing great use made of it in unravelling many of the mysteries of astronomical research.

The death of Dr. Ralph Copeland, Astronomer Royal of Scotland, caused a vacancy, which has been filled by the appointment of Mr. Frank Watson Dyson, M.A., F.R.S., chief assistant, Royal Observatory, Greenwich, to the position of Astronomer Royal of Scotland and Professor of Practical Astronomy, Edinburgh University. Dr. Copeland had a varied career; he was born Sept. 3rd, 1837, in Lancashire, was educated at the Grammar School of Kirkham; he emigrating to Australia, spent several years as a shepherd, and then at gold digging. During this period he turned his thoughts to astronomy, and returned home in 1858. During the voyage he observed Donati's comet of that year. He then apprenticed himself to a firm of locomotive engineers, and with some fellow employees established a small observatory. In 1864, trade being dull, he went to Germany to study astronomy and matriculated at Gottingen University, was appointed volunteer assistant at the observatory, and with Carl Borgen made the Gottingen Catalogue, published in 1869. His next experience was a voyage to the Arctic Regions to explore Greenland's east coast, and for his meteorological and magnetical researches he was decorated with the order of the Red Eagle by Emperor William I., after which he was appointed assistant to Earl Rosse at Birr Castle for three and a half years. In 1876 he was appointed to take charge of the Dunecht Observatory of Lord Lindsay (now the Earl of Crawford); in 1879 he was assistant at Dunsink Observatory under Sir Robert Ball, and in 1889 he was appointed Astronomer Royal of Scotland, (in place of Professor Piazzi Smyth, who had retired), holding the position to the time of his death. This is certainly a remarkable career for one who had served in Australia

in the humble capacity of shepherd; he had by his own efforts raised himself to an honourable position. He died October 27th, 1905, in his 69th year.

Sir Humphrey Davy's memory has been honoured during the year by the erection of a tablet placed on 3 Rodney-place, Clifton, Bristol, in the house he occupied for a time. The unveiling was performed by Mr. Marconi.

Library.—Books and periodicals have been purchased at a cost of £80 16s. 2d., binding books cost £12 11s. 6d., total £93 7s. 8d.

Exchanges.—Number of Institutions on the Exchange list 431; publications received in exchange for the Society's Journal and Proceedings during the past year:—250 volumes, 1824 parts, 165 reports, 185 pamphlets, 17 maps, 1 atlas of charts and 1 photograph, total 2443.

Papers Read in 1905.—During the past year the Society held eight meetings at which 15 papers were read; the average attendance of members was 29·5 and of visitors 1·2. The papers read at each general meeting were not perhaps so numerous as during recent years, but were of considerable value, they are:—

I.—PRESIDENTIAL ADDRESS. By C. O. BURGE, M. Inst. C.E., Telford Medallist, Inst. C.E.

II.—On the occurrence of Calcium Oxalate in the Barks of the Eucalypts. By HENRY G. SMITH, F.C.S., Assistant Curator, Technological Museum, Sydney, [*With Plate*]

III.—On so-called Gold-coated Teeth in Sheep. By A. LIVERSIDGE, LL.D., F.R.S., Professor of Chemistry, University of Sydney.

IV.—Observations on the Illustrations of the Banks and Solander Plants. By J. H. MAIDEN, Government Botanist, and Director of Botanic Gardens, Sydney.

V.—The refractive indices, with other data, of the oils of 118 species of Eucalypts. By HENRY G. SMITH, F.C.S., Assistant Curator, Technological Museum, Sydney.

VI.—Note on the drift of S.S. "Pilbarra." By HENRY A. LENEHAN, F.R.A.S. [*With Diagram*]

VII.—Reinforced Concrete, Paper III. By W. H. WARREN, Wh. Sc. M. Inst. C.E., M. Am. Soc. C.E., Challis Professor of Engineering, Sydney University.

VIII.—On the occurrence of Inclusions of Basic Plutonic Rocks in a Dyke near Kiama. By C. A. SÜSSMILCH, F.G.S.

IX.—Note on some simple Models for use in the Teaching of Elementary Crystallography. By W. G. WOOLNOUGH, D. Sc., F.G.S. (Communicated by Prof. T. W. E. DAVID, B.A., F.R.S.)

X.—Provisional Determination of Astronomical Refraction from observations made with the Meridian Circle Instrument of the Sydney Observatory. By C. J. MERFIELD, F.R.A.S., Mitglied der Astronomischen Gesellschaft.

XI.—Latitude of the Sydney Observatory. By C. J. MERFIELD, F.R.A.S., Mitglied der Astronomischen Gesellschaft.

XII.—A method of separating the Clay and Sand in Clay Soils, and those rich in organic matter. By L. COHEN, Chemical Laboratory, Department of Agriculture. (Communicated by F. B. GUTHRIE, F.I.C., F.C.S.)

XIII.—Sociology of some Australian Tribes. By R. H. MATHEWS, L.S., Corres. Memb. Anthrop. Soc., Washington.

XIV.—On an undescribed species of Leptospermum and its Essential Oil. By RICHARD T. BAKER, F.L.S., Curator, and HENRY G. SMITH, F.C.S., Assistant Curator, Technological Museum, Sydney. [*With Plate*]

XV.—Note on a hollow Lightning Conductor crushed by the discharge. By J. A. POLLOCK, Professor of Physics, and S. H. BARRACLOUGH, Lecturer in Mechanical Engineering, in the University of Sydney, [*With Plate.*]

Section.—The Engineering Section held four meetings at which the following papers were read:—

1.—Annual Address. By S. H. BARRACLOUGH, B.E., M.M.E., Assoc M. Inst. C.E., Chairman of the Engineering Section.

2.—Notes on a tour through America, Great Britain and Europe. By HENRY DEANE, M.A., M. Inst. C.E.

3.—Some Notes on the Storage and Regulation of Water for Irrigation Purposes. By T. WHITCHURCH SEAVER, B.E. (Communicated by W. E. COOKE, M.E.)

Lectures.—The following Popular Science Lectures were delivered during the Session:—

May 30, 1905—"Stellar Evolution," by Prof. BICKERTON.

August 18, 1905—"The Monotremes and the origin of Mammals." by J. P. HILL, D. Sc., F.L.S.

Earthquakes.—At the commencement of our session the second great earthquake of modern times was recorded, visiting northern India, devastating the country for miles, and causing many casualties. Eighty per cent. of they population of the district were killed or injured; 7 European children and 470 Ghurkas were killed by the fall of some stone barracks. The latest estimate of the loss of life (May 25th) gives the total deaths at 20,000. The earthquake originated in the western Himalayas about Dharmasala, its intensity increased through the Punjaub and the United North-west Provinces, and while from Rajpootana northwards it decreased rapidly; apparently there was no wide extension of the disturbance towards Assam and Afghanistan. Dr. Charles Davison in a recent paper states that the earthquake area included about 17,000 square miles.

Professor David gave a very interesting account of the track of these disturbances, showing how they encircle the Pacific Ocean, and also showing the tendency of all steep grades, *e.g.*, the Mount Lofty Range in South Australia, to be visited frequently by such tremors, and pointing out that the weighting of the earth due to the silt and deposits brought down by the rivers, increases the liability to be affected. The previous large earthquake in India was that of June 12th 1897; it extended from Delhi on the west to Siam on the east, and beyond the Himalayas in the north, to Hyderabad in the south, so that it must have been felt over an area of at least 1,200,000 square miles.

At Shillong, Assam, where the earliest movements were recorded at 5 h. 15 m, a deep rumbling preceded the shock by about two seconds, the greatest violence immediately following—in all two or three seconds; the buildings were razed and a peculiar pink cloud of plaster dust was seen hanging over every house at Shillong at the end of the

shock. Again on June 2nd, Turkey reported an earthquake in Scutari, Albania, doing enormous damage—200 persons were killed and injured and houses wrecked. The shocks were severe at Montenegro, and the Bjelkastra mountain was in volcanic activity. Other small shocks were noted during the year, on September 2nd, from Stirlingshire and Perthshire in Scotland. On September 8th, an earthquake in Italy destroyed Pizzo, Martirano and Monteleone de Calabria, involving a loss of 350 lives and £4,000,000 in property.

Several earthquake disturbances were reported from Vienna; the seismograph at the Pola Hydrographic Station registered between 3 h. 55 m. a.m. and 4 h. 17 m. a.m. on Sunday 23rd July, 1905, the occurrence of a severe and protracted seismic disturbance at an estimated distance of some 3,720 miles. Telegrams from St. Petersburg state that earthquakes occurred in Siberia at that time, and a shock was felt in parts of Scotland at coincident times. Another shock was felt at Stirling, Dollar and Alloa in Scotland shortly before midnight on Thursday, September 21st, 1905. The shock travelled in a similar direction to that of July 23rd, namely to the south-east, but it was of slightly longer duration and more violent in character, moving furniture, pictures, etc., and a sound like thunder was heard; at Corton railway signal cabin all the bells were set ringing. At Bridge-of-Allan the shock was decided; in Bannockburn and in the neighbouring villages the impression was of a serious explosion.

The coast of the Republic of Columbia on February 15th 1906, was greatly damaged by an earthquake, which was accompanied by a rising sea. The Port of Boca-Grande was "swallowed up," many persons were killed and injured. On February 19th a severe earthquake occurred in the island of St. Lucia, Windward Islands. Every building in the town of Castries, the capital, was damaged.

The greatest earthquake on record occurred November 1st, 1755, causing great damage and loss of life, extending over all Spain, throughout other parts of Europe to Scotland, North Africa, and in one of the towns of Morocco 10,000 people perished. Six hundred feet of water was afterwards found where the quay stood at Lisbon; the effects of the wave were noticed far out to sea; it swept the whole coast of Spain, Portugal, Madeira and across the Atlantic and both shores of the West Indies.

In March the Tokio correspondent of the *Daily Telegraph* reported that in the earthquake at Formosa thousands of people were killed. The whole island was shaken, and several towns were completely destroyed. The damage was estimated at £9,000,000. In one district alone 1,000 persons were killed and 700 injured.

The Total Eclipse of the Sun on August 30th, 1905.—This event excited much interest amongst astronomers in the northern hemisphere, and all who could take part did their best to record the various phenomena. Unfortunately many were disappointed by the cloudy state of the weather during the few minutes (3·6) that the period of totality lasted. The following gives an outline of the various parties' experiences:—

The westerly end of the line of totality at Labrador was cloudy. Sir W. Macgregor, Governor of Newfoundland, and E. W. Maunder were at Canada under Dr. King at Hamilton Inlet. At Burgos in Spain, the overcast sky greatly interfered, but some photographs of the corona were taken through broken clouds. At Oropesa, east coast of Spain, Professor Callendar of the Royal College of Science was unfortunately entirely shut out by clouds from taking any observations. Torreblanca, only a little north of Oropesa, had quite clear sky, and the observer describes the corona as being very bright and with clearly defined

edges—like "fortifications." The light generally was so great that he was unable to detect any stars; Venus was visible. The prominences were of a violet colour, well defined at the commencement and ending, but not during the totality. This might give a practical clue to the height of the prominences.

At the Balearic Islands uncertain weather conditions prevailed; near Palma, the Solar Physics Observatory party had a good position. Sir Norman Lockyer's party included Dr. F. W. S. Lockyer, C. P. Butler, Howard Payn, F. McClean, and a number of officers and men of H.M.S. *Venus;* under the unfavourable conditions they succeeded in getting some fairly good results. In the centre of the town of Palma, Mr. Crommelin and other English astronomers took up their position on the hotel roof, and also had fairly good observations; shadow bands were observed; a few miles from the town clear sky was·noted. Many of the parties preferred viewing the phenomena from steamers anchored in the line of totality in preference to staying in Spanish towns.

On board the *Ortona* the prominences were well seen, being described as "rose-colour" with bases of yellow, noted on one side of the sun at a time; the corona of "a soft pearly blue," with streamers projecting about two diameters, two pairs "above and below" the Sun; Venus, Regulus, and Mercury were visible. On the "*Arcadia*," Baily's beads and the shadow bands were observed. The conclusions were that the corona was very compact, bright and of a silvery hue. Only one ray stretched out conspicuously from the corona—four or five minor streamers also showed themselves—but paler than usual; the temperature fell from 82·4 to 72·5. Fine weather, better than they obtained at Palma, was experienced at Phillipville, Algeria, where the Solar Physics Observatory party originally intended to locate.

At Guelma favourable conditions occurred, and Mr. Newall made many good observations with the Cambridge great spectroscope; M. Tripied, Director of the Algiers Observatory was at this place also. The corona was reported very bright, not extensive, and uniformly distributed round the sun. Red protuberances were well seen and also Baily's beads, Mercury, Venus, and Regulus were visible; the temperature fell during the eclipse from 91° to 82°; shadow bands were observed.

The Astronomer Royal of Greenwich was at Sfax, in Tunis, assisted by the crew of H.M.S. *Suffolk;* a French party was also there, under M. Bigourdeu: partial cloud interfered, and the eclipse was fairly well observed and photographed; nothing extraordinary was noted in the corona, which was of the characteristic maximum type, with streamers extending as much as two diameters from the disc, and of a "rosy colour." There was no definite beginning to the eclipse, the crescent never wholly disappeared, or rather it merged into a magnificent group of prominences spread over an arc of almost 30 degrees, near the spot where the last of the sun's true disc was seen. They must have been of immense height, and it seemed at least 30 seconds before they were hidden by the advancing moon; at the same time, gradually too, the corona emerged. Observers who have seen many eclipses say it was but a poor corona; to others it did not seem so. In place of the sun's crescent an inky black disc hung in the sky, with a great span of rosy prominences east of its vertex, and at all other parts of the circumference streaks and streamers of pale but defined substances were set with the strangest irregularity, brilliant, round the edge of the disc, and lost to the eye some two diameters distant. Many observers saw a rosy tint in it; others called it a pure silver or aluminium grey. It was most unmistakably

of the type associated with sun spot maxima. Many stars were visible, though the sky was never very dark. Too soon its 200 seconds duration were gone, and with amazing brilliance the sun's disc began to appear. Most of the observers took successfully as many as seven photographs out of eight.

In Tripoli, Professor Todd observed under favourable conditions. The American Expedition from Amherst College set up their station at the British Consulate. Shadow bands were seen 10 minutes before totality, and had many remarked and pronounced peculiarities, wavering and narrow, moving swifter than one could walk, at right angles to the wind, their length with it, and waxing and waning five times during the eight minutes preceding totality. Baily's beads were photographed. The corona was "not impressive," being evenly developed, with long streamers. Other parties under Professor Millesovici of Rome, and M. Libera of Paris, were at the same station.

At Assouan on the Nile, there were parties of three nationalities—British, American, and Russian. Professor Turner, of Oxford, assisted by Mr. Bellamy, observed specially the corona light; Captain Lyons and the officers of the Survey Department obtained five exposures with the astrographic telescope, one with a green screen and one enlargement, six polarised by reflection in the horizontal plane and two in a vertical plane.

Mr. Gunther of Magdalen College, Oxford, obtained with a Goertz lens, six plates for comparion with similar ones taken at Labrador. The party of the Lick Observatory under Professor Hussey, had similar instruments to those used at Labrador, so that any change in the corona might be detected; the sky was hazy which detracted somewhat from the clear view of the corona; change of temperature very slight. The corona appeared small with its longest

streamer to the S.E. about 2 diameters long and three shorter ones. A very interesting article[1] by Mrs. Hussey detailed the arrangements of the Expedition.

As there would be considerable duration of the passage of the moon's shadow across the earth, it has been supposed that it might be possible to detect the progress of some change in appearance in special parts of the corona, due to any process of disturbance that might be going on there, particularly if they might be situated above a large prominence in active eruption. Some slight indications of this kind have indeed been seen, but it was especially hoped that they might be established by means of photographs intended to be taken last August in Labrador, when compared with others taken with similar instruments in North Africa. The distance apart of the places of observation would have allowed a difference in time of fully two and a quarter hours. It was therefore thought that some clearly distinguishable change of appearance might occur in that length of time. But the sun was wholly obscured by clouds in Labrador, as so often happens in connection with some specially important observation; the weather was at its worst where it was most needful that it should be fine, and the journey to a most inhospitable region was all in vain. The desired comparison must consequently be postponed until another suitable opportunity shall again occur, in which it may be possible to find accessible and suitable localities for the observation situated at a long distance apart on the earth's surface.

The following notes are extracted from W. J. Hussey's Report on the Eclipse, August 30th 1905: Nineteen photographs were obtained, having exposures varying from half a second for the inner corona, to sixty-four seconds for the fainter outlying streamers. With the intra-mer-

[1] Independent Magazine, November, 1905.

curial apparatus the time of totality was divided as nearly as might be to obtain duplicate plates along the ecliptic in the vicinity of the sun. The exposure with the spectrograph lasted throughout totality, except for a second or two at the beginning and the end. No detailed study of photographs is made at an eclipse camp. This requires the resources of measuring-engines, microscopes, comparison-plates, and other records. At the observing station the one object is to bring out all the detail the plates will yield and fix them against the chance of accident from light or chemical change.

Professor M. Moye at Alcala de Chisvert, a little town on the east coast of Spain, was favoured with a clear sky, observations were restricted to the shadow bands, and he describes them; they were greyish ribbons, not black, tolerably distinct and wavy:—

"I noticed their direction from S.W. to N.E. and their motion perpendicular to this, *i.e.*, from N.W. to S.E., both before and after totality. The shadow bands reminded one of a rope tied at one end and made to wave by the hand at the other end. At the totality, light was surprisingly bright, had no difficulty in sketching or reading small letter press, features of landscape, details of railway engine; divisions of watch easily seen. Owing to the general illumination, decidedly lighter than a full moon night, I was unable to see any star or planets, with the exception only of Venus. The eclipse wind was very noticeable, coming to a perfect calm some minutes after totality; temperature in shade fell about 5° Fahr."

Observations of these shadow bands hitherto made have been quite discordant, and the cause of the phenomenon is not known with certainty, although there are theories, one of these assumes that the bands are a diffraction effect when the sun becomes a narrow strip; another is described by Professor Cleveland Abbe, this, he says, should not be

called a diffraction phenomenon, though it does occur when a thin sheet of light from the edge of the sun passes the edge of the moon at the moment of totality. The diffraction bands would necessarily move onward over the earth's surface with the same relative speed as that of the moon and the earth, approximately a mile a second, whereas the observed shadow bands have a velocity of only a few feet or yards per second. On the other hand, the bands may be considered as phenomena of interference of rays of light slightly inclined by reason of the irregular refractions in a non-homogeneous atmosphere.

M. Deslandres directed the Bureau des Longitudes Mission to Burgos, where the actual duration of visible totality was curtailed by clouds to one minute, which did not include either the second or the third contacts. The proposed photographing of the chromosphere spectrum was therefore impossible. Photometric observations of the corona were obtained, and M. d' Azambuja was able to measure the corona radiation, obtaining figures which were decidedly lower than those obtained by M. Charbonneau in 1900. M. Kamapell obtained four photographs of the corona polarised by reflection. M. Blum obtained two photographs of the corona through coloured screens so arranged as to transmit only the gaseous radiation of the prominences. By comparing these with the ordinary photographs, it will probably be possible to determine whether or not the prominences emit a more intense continuous spectrum than that emitted by the surrounding regions. At El Arrouch, 32 km. from Philippeville, M. Andover simply attempted to obtain as many direct photographs of the phenomena as possible. His instrumental equipment consisted of a photographic objective of 14 cm. (5·6 inch) aperture and 60 cm. (24 inch) focal length, mounted with two enlarging cameras which increased the diameter of

the image by three and eight times, respectively. Altogether 44 plates were exposed, eleven of these during totality. A negative exposed two minutes before totality, shows a reversed image, due to over-exposure, and a silhouette of the corona.

Attention has recently been given during total eclipses to the question of the existence of any planet or planets nearer to the sun than Mercury. Such planets, if so situated, would be illuminated by a very intense solar light, if only one-half or one-quarter of the diameter of Mercury. It might be possible that such planet could be hidden in some eclipses of the sun or moon, or its light be overpowered by the corona, if our line of sight to it pass very near the sun; but, if so, it should be visible in other eclipses when in other parts of its orbit; up to the present no such planet has been detected. In the eclipse of May 18th, 1901, the remarkably long duration of totality ($6\frac{1}{2}$ minutes) was very favourable for these observations. Unfortunately for some time to come there will not be so good an opportunity to observe. In 1907, it would involve a trip to Turkestan or Mongolia; in 1908, or 1911, to the Pacific, and in 1912, when the very rare occurrence of two total eclipses (only six months apart) will take place in South America and the Spanish peninsula; these will be of short duration. In 1919 an eclipse of long totality will be visible in Brazil and central Africa.

Changes on the Moon's surface.—From time to time, astronomers who make special studies of the lunar surface, have intimated their belief that changes of various kinds may be occurring on the surface of our satellite. Professor W. H. Pickering, as the result of a long series of special observations in Peru, Jamaica, and California, believes that physical changes do occur, and that they may be classified under three heads, due respectively to

(*a*) volcanic action, (*b*) formation and melting of hoar frost, (*c*) vegetation. The first class is illustrated most forcibly by the crater Linné, which according to Lohrmann, Mädler and Schmidt, prior to 1848, had a diameter of between four and seven miles, whereas its present diameter is three-quarters of a mile. A new crater has also been announced in the vicinity of Hyginus. The floor of the crater Plato has repeatedly furnished new formations at various times—Pickering's latest observations show the existence of a crescent-shaped bank, six miles long by one or two miles broad, not shown on maps made by A. S. Williams during the period of 1879-1890. Turning to the second class of changes, there appears to be numerous examples of formations which would be most simply explained by supposing them to be composed of hoar-frost. It is considered that the strongest evidence that water in the liquid state ever existed upon the surface of the moon lies in the dried up river-beds of which the best example lies on the eastern slopes of Mount Hadley, at the base of the Appenines. Another, discovered only in the summer of 1904, lies about 60 miles due south of Conon. The author also brings direct observational evidence to show that changes in the forms of lunar features *e.g.* the small craters Messier and Messier (*a*) may be actually seen to vary with the period of the lunar day.

Regarding the third class of variable phenomena, these are stated to be more conspicuous than those due to the former two causes.

Reproductions are given in the paper of four photographs obtained in Jamaica in 1901, showing distinct evidence of changes on the crater Eratosthenes with the age of the moon. Every precaution has been taken to exclude any conclusions based on changes of shadow resulting from

varying illumination; but after all, it is quite certain that intrinsic growths of dusky matter have taken place, and as no mineral is known which could give this appearance, it is ascribed to the growth of vegetation. As the lunation progresses the western portion of the dark area slowly fades out, and the eastern is absorbed in the growing shadows of the lunar night. A more detailed account of the phenomena will be found in Harvard College University Annals, Vol. 53. In a paper called "The reality of supposed changes on the moon's surface," M. Puiseux discusses at some length the various observations of alleged changes on the lunar surface under the influence of the solar radiation. Going back to the earliest observations of details, he considers each authoritative report of suspected change up to the most recent observations of the reported increase of the diameter of Linné during lunar eclipses. Summing up the evidence thus examined, M. Puiseux arrives at the conclusion that the case for real changes taking place on the surface of our satellite is not established. He believes that the change of sensitiveness of the retina when observing faint objects is sufficient to account for the changes usually observed, whilst the different conditions of exposure when photographing the eclipsed moon might easily introduce the changes suspected from the examination of photographs.

Mars.—Mr. G. D. Hirst, F.R.A.S., who was president of the New South Wales branch of the British Astronomical Association 1904-1905, during the 1905 opposition of the planet Mars, obtained some good drawings of more than special interest, and has been pleased to give the Observatory copies from which lantern slides have been made and colored very delicately, but no signs of the canals were shown with the optical facilities he possessed.

Even with the largest telescopes yet made, these markings are not so clearly defined as to cause the acceptance of them as positive. The Savilian professor of astronomy at Oxford, Herbert Hall Turner, F.R.S., has the following remarks on this subject:—

"We have heard a good deal of late years of the canals of Mars, and there is no doubt at all that certain straight markings on the planet's surface have been detected. Many of us have sufficient faith in that wonderful observer Schiaparelli to believe that these are occasionally seen double. But as regards the interpretation of such markings—the notion that because they are called canals it is implied that there are inhabitants on Mars, who have dug them for irrigation purposes—we must exercise more caution. To realize the value of our information, consider first how much further away Mars is than the moon—about 200 times at least, and generally much more. Now 200 is the magnifying power of a good telescope, that is to say, the magnifying power which can be used with advantage. It follows then, that whatever a fair telescope enables us to see on Mars could be seen on the moon with the naked eye; and it may be added that whatever the largest telescope in existence would enable us to see on Mars could be seen on the moon with a pocket opera-glass, for our gain from the recent increase in size of telescopes is well within that represented by a small opera-glass as compared with the eye. Hence, let any one look at the moon with the naked eye, or even with a small opera-glass for traces of canals or other signs of life of any kind, and he will begin to understand the caution which must be exercised in drawing conclusions, however attractive, as to the habitability of the planet. We want, in fact, an increase of our optical resources by a thousand times at least to get any satisfactory intelligence of this kind, whereas the advances of the last century would be represented by a factor not greater than 10, and there seems no chance at present of our getting to 100; we might manage 20, perhaps, by slow and costly advances, but 100 seems impossible.

A brief statement, and especially a numerical statement, of this kind should not be criticised too closely in detail; but it may be accepted unhesitatingly as giving a general idea of the situation. Professor E. E. Barnard, who has had probably more experience of the largest telescopes in favourable conditions than any one, is of opinion that the naked eye view of the moon better represents the view of Mars through the best telescope."

Professor W. H. Pickering states that on examining a number of photographs of Mars, which were secured with the 11-inch Draper telescope during March 31st to April 30th, 1905, it was seen that no snow-caps properly so-called appeared until April 23rd. The photograph of March 31st showed clouds on both the terminator and the limb, but no polar caps. On April 23rd, a clearly visible and extensive light area appeared at the southern pole, but was not bright enough for snow, rather resembling an extensive region of clouds. A very small light area appeared near to the northern pole on April 15th, but was only seen with difficulty; a visual examination with a 24-inch reflector revealed the southern polar cap on April 30th, as extending far towards the north in longitude 340°. Professor Pickering thinks that when the clouds disperse snow will probably be revealed lying in their place. He also contends that the observed seasonal colour, changed from brown to green, on such features as the Mare Erythræum is the surest evidence of the existence of vegetation on Mars.

Sixth Satellite of Jupiter.—This new satellite was discovered while observations were being made with the 36-inch Crossley reflector at the Lick Observatory during December 1904, and was confirmed by further observations on January 4th, 1905. Perrine, the discoverer, states that its distance from the planet on the latter date was 45′ so that it is situated at a considerably greater distance

from the primary than any of the other previously known five satellites. Its photographic magnitude was fourteen, so that it is fainter than the fifth, which was discovered by Barnard in 1892.

Seventh Satellite of Jupiter.—A telegram containing a message from Campbell was received stating that the previously announced discovery of a seventh satellite to Jupiter had been confirmed; it was discovered by Perrine with the Crossley reflector at the Lick Observatory. The Astronomer Royal of England exhibited and explained some photographs of the sixth and seventh satellites of Jupiter, obtained with the 30-inch reflector of the Thompson equatorial of Greenwich. The results of the provisional measures of the photographs, and their comparison with the angles and distances given by Dr. Ross's ephemeris, the dates, and exposures are given in No. 1 VOL. LXVI of the Monthly Notices. The exposures for the seventh satellite varied from 17 to 177 minutes.

Solidification of the interior of a Planet.—MM. Lœwy and Puiseux have a short note concerning the extensive enquiry prosecuted by the authors into the evidence bearing on the physical state of the lunar crust as determined from a minute study of the features of the moon's surface on the photographs taken with the equatorial Coudé at the Paris Observatory. Starting with a short reference to the views of Kelvin, Darwin, King, and Barns, advocating the view of the earth's solidification as opposed to those of Suess and Lapparent, who think it to consist merely of a thin solidified crust enclosing a liquid viscous interior, the evidence supplied by the lunar formations is discussed and considered to favour the latter view. As evidence supporting the idea of gradual solidification from the surface inwards, the successive terrace formation seen in many lunar craters and seas is

cited. In almost every case there appears evidence of five successive stages of solidification and consequent retreat of the confined fused materials. Some of the definite objections to this theory of solidification from the outer parts inwards are discussed and criticised in detail.

Saturn.—Professor W. C. Pickering of the Harvard University has discovered a tenth satellite of Saturn. The stages of the discovery from the first suspicion of its presence to the confirmatory evidence extended over some years. The discovery of the ninth satellite was also made at Harvard Observatory by Bond. The new satellite has a period of revolution of twenty-one days, or a little less than that of Hyperion, a near by satellite, which revolves around Saturn in twenty-one days and six hours; it has an estimated diameter of 200 miles, and just beyond even telescopic vision, and only the sensitive plate can catch it, the motion of the satellite is direct—against the hands of the watch viewed from the north in the plane considerably inclined from the plane of the rings. Observations of the satellites of Saturn and Uranus involving some hundreds of individual settings were made by Messrs. Frederick and Hammond with the 26-inch equatorial of the United States Naval Observatory during 1904.

Secondary shadow of Saturn's rings.—In the course of a series of observations of the planet Saturn at Aosta, in Italy, during the latter part of 1904, a secondary shadow was seen projected on the rings. It was definitely noted that the new shadow was curved, but in the opposite sense to the primary. The curvature appears to vary irregularly, sharply defined on the side nearest the planet; the shadow becomes attenuated towards the exterior border, while on drawings made from December 22nd-27th, there is shown a bifurcation of the part of the secondary shadow which was projected on the inner ring. Taking

the equatorial diameter of Saturn as unity, the mean distance of the shadow from the edge of the disc was found to be 0·13. All the observations were made with an equatorial of 17 cm. aperture and 2·02 m. focal length, using powers from 157 – 350 diameters, under atmospheric conditions generally very favourable.

Lost Double Star.—A remarkable chapter of coincidences is recorded in No. 7, VOL. XIII of Popular Astronomy, by Professor Doolittle, of the Flower Observatory, U.S.A. In Sir John Herschel's first catalogue of double stars, No. 165 was described as a 3″ pair with a position angle of 330°, its position being given as R.A. 10h. 26·8m., Dec. + 12° 32′ (1825). In 1878 Professor Burnham directed his attention to the pair and recorded position angle as 205°.3′ and distance 2·59″. Again in 1901 he observed the double with the 40-inch refractor, and obtained a measure agreeing with Herschel's record, but in 1902 he could find no trace of the pair observed in the previous year, nor of the star measured by him in 1878. Observations made in 1905, with the 18-inch refractor of the Flower Observatory, failed to reveal the double given by Herschel, but showed a very wide faint pair in the exact position given by him. Thinking that Professor Burnham in 1901 might have confused the sign of the declination, Professor Doolittle turned his telescope to the same R.A. and Dec. minus 12°, and there apparently found exactly the pair that was wanted. This seemed to have cleared up the mystery; Professor Burnham had in 1901 observed the wrong star. A letter from that observer showed, however, that this is not the correct explanation. The truth is that Herschel made a mistake of exactly one hour in recording the R.A. of H.165, and Professor Burnham had, unwittingly, made precisely the same mistake in 1901. Thus the latest observation of Herschel's

No. 165 shows its position to be R.A. 9h. 31m. 13s.— Dec. = + 12° 25′ (1880), and its position angle and distance, at the epoch 1905·38, were 333° 1′ and 2″04 respectively. In 1878, Professor Burnham, observing in the position given by Herschel, saw a pair which was not identical with H. 165, and in the year 1902 was too faint for him to see. In 1901, repeating Herschel's mistake in the R.A., he observed the true H.165, whilst in 1905 Professor Doolittle found a similar pair to H.165 in the same declination south and in the R.A. given in mistake by Herschel.

Magnetic Storms and Sun Spots.—William J. S. Lockyer M.A., Ph.D., remarks :—

" During the year several interesting papers have been read on the subject of the magnetic disturbances 1882-1903 as recorded at Greenwich. The relationship between sun spots and the occurrence of these storms is evidently not yet solved, for to mention simply two of the deductions arrived at — Professor Schuster sums up his remarks in the following words :—" At present we are only able to form more or less plausible guesses as regards the necessary mechanism," while Father Cortie comes to much the same conclusion, that no law has been established. An important question relative to the above problem is what is the period of rotation of the sun at sun spot level, and does this period remain the same at sun spot minimum and maximum ' Dr. Halm has shown that the spectroscopic observations at the level he examined exhibited different values of the velocity at maxima and minima for corresponding latitudes, and the differences in the velocities increase, the greater the heliographic latitude of the level at the solar limb. This important research, which has now been published more than a year and a half, opens up a field of inquiry of great interest."

Distribution of Actinic Sunlight on the northern hemisphere at summer solstice is considered, the conditions would reasonably be supposed to apply also to the southern hemi-

sphere. Mr. J. Sebelien (Phil. Mag., March 1905), after briefly reviewing the work of Halley and other authorities, brings together some values obtained by Bunsen and Roscoe into tabular form, showing the extent to which diffused daylight tends to equalise the numbers for the total quantity of light at the different latitudes. It is further shown that while at the equator the effect of the direct insolation on the said day has double the value of the daily effect of the diffused daylight these numbers will become equal in the neighbourhood of 49° north latitude, the further we get towards the north or south (if in the southern hemisphere) the more diffuseddaylight will dominate. Also it is shown that the preference conferred upon the northern and southern latitudes with regard to their actinic illumination at the equinoxes will increase with the declination of the sun, and reach its maximum value at the summer solstice. Then using the formulæ of Bunsen and Roscoe, Mr. Sebelien has calculated the quantity of actinic light which on a midsummer day falls upon an horizontal element of surface from sunrise to sunset for every tenth degree of latitude; the resulting values are plotted graphically.

Meteorites.—H. E. Wimperis states that it is probable that the velocities of meteorites are by the resistance of the atmosphere changed by a fractional part of the velocity, which fraction is independent of the velocity of approach; that the superior limit for incandescence is about 150 miles above the earth's surface, and that no iron meteor, the original weight of which was less than 10 to 20lbs, reaches the earth's surface, and that when a meteor does so, the temperature of its centre is not in general above that of liquid air (assuming the temperature of space to be absolute zero).

Zodiacal Light.—A. H. Hansky gives details of observations made on the evenings of September 21-22, 1904, at the observatory on the summit of Mount Blanc :—

Under the exceptionally fine conditions it was possible to see that the form of the zodiacal light was a spherical triangle, with its apex near the ecliptic. At the time of observation (3h. 40m. Paris mean time) the height of the apex was 52 degrees; the length of the light, reckoning from the centre of the sun, 80 degrees, and its width at the horizon 25 degrees. The intensity increased towards the centre, but its maximum was not situated on the ecliptic, being about 3 degrees from it. Three zones were distinguishable in the body of the light, that described above, and of general feeble luminosity; a medial portion slightly parabolic in outline, and a central luminosity in the form of a parabola. As an approximate measure of intensity, the light at 55 degrees from the sun was estimated to be equal to that of the Milky Way, at 40 degrees about double this, and at 30 degrees three times. The colour was very difficult to define on account of the faintness of the light, but it was thought to be white with a trace of green. The paper concludes with various suggestions concerning the probable cause of the phenomenon.

Reflecting Powers of Glass and Silvered Glass Mirrors.—Mr. C. A. Chant in a paper read before the Royal Astronomical Society of Canada, presents a review of former investigations on the reflecting power of various substances. For perpendicular incidence on numerous metals and alloys for wave-lengths ranging from 250 to 1500 mm., the general conclusion is that the reflectivity increases with the wave-length. Work on glass mirrors shows that the reflection will gradually fall off with age, although there may be no perceptible tarnish on the polished surface. A special arrangement was a photometric optical bench to admit of the mirror under comparison and its illuminant (a Hefner lamp) to be

turned together through any determined angle. Measurements of the light intensities were made with a Lummer-Brodhura photometer, arranged for equality of contrast. Tables and curves are given showing the results obtained at varying incidences with different types of plain glass and silvered surfaces. The initial superiority of silver before glass is about 6 per cent., but when the factor is considered, the silver behind glass is much more permanent in reflecting power. Thus a silver-fronted mirror after three months' exposure had fallen to 68 per cent., whereas an ordinary commercial back-silvered mirror at least three years old, was still capable of reflecting 86·7 per cent. of the incident light.

Lectures on Meteorology.—The Council of the Royal Meteorological Society, London, being desirous of advancing the general knowledge of Meteorology and of promoting an intelligent public interest in the science, has appointed a lecturer, who is prepared to deliver lectures to scientific societies, schools, and institutions, on payment of a moderate fee and the cost of travelling expenses. The subjects are:—How to observe the weather, weather forecasting, climate, rainfall, thunderstorms, meteorology in relation to agriculture, health, etc. The Society is also prepared to lend and fit up a complete climatological station for exhibition, showing the necessary instruments in position and ready for use, and to lend, for a nominal sum, sets of lantern slides illustrating meteorological phenomena. This is work that could with advantage be introduced and carried on in our State.

Bruce Telescope of Yerkes Observatory.—Details are given of the construction and performance of an important addition to the instrumental equipment of the Yerkes Observatory—a photographic doublet of 10 inches aperture equatorially mounted, with subsidiary companion teles-

copes of 5 and $6\frac{1}{2}$ inch aperture clamped to the same frame–work. As for the work planned with this instrument it is necessary to make long uninterrupted exposures; the mounting has been so designed as to give a continuous motion across the meridian without reversal of the telescope. The focal length of the 10 inch lens is only 50 inches (128cm.) so that it is exceedingly rapid; it gives exquisite definition over a field about 7° in width, and by careful averaging may be made to cover a region of 9°. The plates used are 12 inches square, and the scale of photograph such that 1in = 1·14° or 1°. = 0·88 inch. Guiding is performed with a high power eye piece on a 5-inch telescope. For use in southern latitudes reversal gearing is provided in the driving train from the clock. The instrument was taken in December, 1904, to Mount Wilson, in Southern California, where there is being established a branch Observatory of the Yerkes Institution. It is intended to replace the $6\frac{1}{4}$ lens by a new one of Jena glass, and an objective prism of the same aperture for spectroscopic investigation.

The Mount Wilson Observatory.—E. W. Maunder, F.R.A.S., gives the following description of the Observatory on Mount Wilson, California, U.S.A.:—

A most important step for the advancement of astronomy has been taken by the establishment of a Solar Observatory on Mount Wilson in Southern California, at an elevation of about 6000 feet, in an atmosphere free, through exceptionally long periods, from cloud, water vapor, dust, fog, or wind; its position is in latitude 34° 13′ 46″ north and longitude 118° 3′ 40″, and is not far distant from the cities of Pasadena and Los Angeles. The plan of work proposed includes the following classes of observation:—(1) Frequent measures of the heat radiation of the sun, to determine whether there may be changes during the sun spot cycle in the amount of heat received from the sun by the

earth, and the relative radiation of the various portions of the solar surface. (2) Studies of various solar phenomena, particularly through the use of powerful spectroscopes and spectroheliographs. (3) Photographic and spectroscopic investigations of the stars and nebulae with a very powerful reflecting telescope for the principal purpose of throwing light on the problem of stellar evolution. There will be an attempt to realise more completely laboratory conditions in astrophysical research through the employment of fixed telescopes of the coeleostat type, and through the adoption of a Coudé mounting for the 5 ft. reflector, which will be one of the chief instruments employed. This would permit the use of mirrors or objectives of great focal length, providing a large image of the sun for study with spectroscopes and spectroheliographs, the use of long focus gratings mounted in a fixed position in constant temperature, laboratories, and the use of various laboratory instruments, such as the radiometer, which cannot now be used with a moving telescope. The Observatory will also have a workshop for the providing and designing of new instruments, and for the repair or adapting of the older telescopes. The Yerkes Observatory has lent the Snow telescope, which is already installed on Mount Wilson; this instrument will eventually be returned when the Mount Wilson workshop has provided its Observatory with a similar instrument. The Bruce telescope has also been installed on the mountain during the summer of 1905, and Professor Barnard has been engaged with it in completing his photographic studies of the Milky Way. The present staff consists of Professor Hale, the director; Professor G. W. Ritchey, astronomer and superintendent of instrumental construction; and Professor Ferdinand Ellerman and Professor W. S. Adams, assistant astronomers.

Conference of Australian Astronomers.—From 10th-16th May, 1905, a conference of the Directors of the different Australian State Observatories was held in Adelaide under the chairmanship of Sir Charles Todd, M.A., K.C.M.G.,

etc., the oldest and most honored of our astronomers. He is one to whom we all look up with respect, and was complimented at the close of the conference on the able manner he had conducted the business and the happy way he had of smoothing over the difficulties of discussion. All topics of the various work of each Observatory, astronomical and meterological, were discussed, and consideration given to the proposition of the Federal Government to take over the various State establishments and form them under one control; also the problem of individual State administration. The various views of each member of the Conference were discussed, and a final set of resolutions and recommendations was formulated and embodied in the final report, which was presented later in the month to the respective Ministers of the various States controlling the Observatories. One feature brought out was the accumulated manuscript of astronomical results in the various Observatories, which in my own case (Sydney Observatory) represents the unpublished Transit Circle observations since 1881. I have repeatedly drawn attention to this matter, but have met with the same reply—"the difficulty of obtaining money to publish." This silence on the part of the Sydney Observatory has been questioned adversely, but in the face of the difficulty of getting Ministerial authority to print the matter, the comment is not just. Other recommendations as to the publishing of all results on a formulated basis, so that all the information could be comparable was suggested, and we look forward to this desired uniformity in the future. Much improvement can be introduced and obtained by either one central authority, for certainly meteorology; or by periodically meeting in conference of the heads of the Observatories who will carry out the decisions of the majority. This arrangement

we hope will be for the general good and will raise the tone of work in Australia.

Visit of Dr. Alessio.—On January 8th, 1906, a distinguished visitor in the person of Dr. Alberto Alessio, navigating Lieutenant of His Italian Majesty's ship *Calabria*, visited Sydney for the purpose of verifying the investigations of previous observers in gravity and magnetic variation, dip, and intensity. These observations were carried out on the same sites as previously adopted at the Sydney Observatory, and the comparisons of deductions will be made some time in 1908, when the results of the whole of the places visited by the *Calabria* will be under discussion.

Vastness of the Astronomical Work to be done.—Robert Hall Turner, F.R.S., states that the attention of astronomers has recently been claimed in so many new directions that they cannot possibly do justice to all, and some of the most attractive problems have accordingly failed to attract solvers. The astronomical standing army is a very small one, and much of it is wanted for home defence for keeping a watch on objects already discovered, and doing routine work that must be done. It is nobly reinforced by volunteers, and there is perfect accord between the regulars and the reserve forces. But we are in the presence of a vast extension of the Astronomical Empire and we begin to find how small our numbers are. Is it a vain hope that our ranks may be materially increased shortly? Professor Darwin, president of the British Association, makes allusion to the number of stars visible and probable number in the heavens. Only a few thousand stars are visible with the unaided eye, but photography has revealed an inconceivably vast multitude of stars and nebulae, and every improvement in that art seems to disclose yet more and more. About 20 years

ago the number of photographic objects in the heavens was roughly estimated at about 170 millions, and some 10 years later it had increased to about 400 millions. Although Professor Newcomb, in his recent book on "The Stars," refrains even from conjecturing any definite number, yet I suppose that the enormous number of 400 millions must now be far below the mark, and photographically still grows year by year. It seems useless to consider whether the number of stars has any limit, for infinite number, space and time, transcend our powers of comprehension. We must then make a virtue of necessity, and confine our attention to such more limited views as seen within our powers. A celestial photograph looks at first like a dark sheet of paper splashed with whitewash, but further examination shows that there is some degree of method in the arrangement of the white wash spots. It may be observed that the stars in many places are arranged in lines and sweeping trains, and chains of stars, arranged in roughly parallel curves seem to be drawn round some centre. A surface splashed at hazard might present apparent evidence of system in a few instances, but the frequency of the occurrence in the heavens renders the hypothesis of mere chance altogether incredible.

Expedition to the North Pole.—Commander Peary sailed in July to make a further attempt to reach the North Pole. He intends going by the Smith Sound or American route to the Pole, and force his ship to a base within 500 miles of the Pole itself, and sledge across the polar pack. The arctic ship *Roosevelt* has been built for this expedition, constructed so as to withstand ice pressure, and so shaped that this ice pressure will have the effect of raising the vessel out of water. A wireless telegraphic outfit will be carried, and one or two relay stations in Greenland will keep her in permanent communication

with the permanent telegraph station at Chateau Bay, Labrador, and thence by existing lines with New York; by the same means communication with the Expedition will be possible for some of the distance. In February, 1906, the sledge party intended to move forward for the northern dash. The ship carries two years' supply. A permanent sub-base is established at Cape Sabine, west coast of Smith's Sound, where the services of the necessary Eskimos will be secured. The vessel will be forced through Kane Basin and Kennedy and Robeson Channels to the north coast of Grant Land, or of Greenland, if the conditions compel it, and there winter within the 500 miles limit of the Pole. This dash may occupy five months. In the event of the *Roosevelt* failing to force Kennedy and Robeson Channels during the first summer, the dash for the Pole will be postponed until the following February, 1907.

Reinforced Concrete.—During the session just ended a paper on steel and iron reinforced concrete was before the Society, and the following interesting preliminary report issued by the Mines branch of the Canadian Department of the Interior bears on this question; it has reference to raw materials, manufacture, and uses of hydraulic cements in Manitoba. It has been drawn up by Mr. J. Walter Wells, and involved an examination of the limestones, marls, clays, shales and coal deposits of the province—particulars are added of the cement mills in North Dakota, in Minnesota, and in South Dakota, and much information is given regarding the manufacture of cement from the raw materials available, that cannot fail to be of practical value in furthering the cement industry of Manitoba and generally throughout the world. In that province, timber is becoming scarce, and suitable stone and bricks are expensive; cement is therefore coming into increasing use

in house and farm construction, in railway work, in municipal work, and in factories and mills. Within the last eight years the uses of concrete have been greatly extended by the introduction of iron and steel re-inforcements, consisting of skeleton structures so arranged in the concrete masses, that rods, bars, wires, and bands help in resisting stresses in tension. A very important application of re-inforced cement concrete in Manitoba is the construction of grain elevators. The various applications of cement in the province are well shown in the photographic illustrations of the report.

Decimal System.—An important step in the direction of the adoption by England of a decimal system of weights and measures has been taken by the Board of Trade, in which the Board was asked to authorise weights of 20lbs., 10lbs., and 5lbs., as aliquot parts of the cental. Lord Salisbury writes:—

"Your suggestion that new denominations of weights of 20lbs., 10lbs., and 5lbs., should be legalised for use in trade. The Board of Trade have given careful consideration to the representations which have been made, and they are prepared to assent to the application. Steps will therefore be taken for the preparation of standards of the same octagonal form as the present 50lbs. weight. The Chambers consider that this concession will save time, labor, and expense, as the 50lbs. weight has done already."

A Botanical Congress.—A Botanical Congress at Vienna, June 11th to 18th, 1905, adjourned from Paris, October 1900, was an impressive demonstration of the activity of botany as a science, and of the enthusiasm of its members. Over 600 botanists, men and women, representing nearly all the important, and many of the less important botanical institutions of the world met there (New South Wales was unfortunately not represented). Nearly every European country, America, China, and other countries

sent representatives. The opening of the Botanical Exhibition, in the orangery of the historic palace of Schönbrunn just outside the city, occupied the first day. This exhibition was an exceedingly interesting one, and showed the present position of botany from a teaching as well as from a general view. A series of diagrams and coloured photographic lantern slides of microscopic preparations, flowers and plant associations and other objects; living cultures of Algae—all kinds of apparatus and photographs of tropical vegetation in Brazil, Malaya, etc., were shown. A remarkable feature was the unique specimen of *Fockea capensis*, a member of the family Asclepiadaceae, which, originally brought from the Cape, still remains the only known specimen. The plant has a hard woody rhizome as big as a child's head from which in rainy seasons numerous shoots are developed. It was described and drawn by Jacquin in his "Fragmenta" at the beginning of the last century. Jacquin wrote repeatedly to Sir Joseph Banks' secretary Dryander, and the London Society are pleased to possess these communications together with the many exquisitely delicate drawings. Jacquin's herbarium, consisting largely of plants cultivated in Vienna and the Schönbrunn gardens, was bought by Banks and is now in the general collection of the British (Natural History) Museum. During the sitting of the Congress a bust of Nicholas Joseph Jacquin, who was Professor of Chemistry and Botany at Vienna from 1769-1796 was unveiled in his honour in the Fest-Saale of the University. Quoting from Professor Wiesner's appreciation at the ceremony:—

"His broad horizon and great powers of organisation were shown in the fact that, in the second half of the 18th century, no scientific, and especially no natural scientific undertaking was started in which Jacquin did not take an important part. He embodied the ideal of the academic teacher."

On the same occasion was also unveiled the bust of Jan. Ingenhousz (1730-1799) a Netherlander by birth, who spent the greater part of his working life in Vienna. He was physician to the Empress Maria Theresa and the Emperor Joseph II. Botanists know him best as one of the earliest workers in the sphere of plant physiology. The principal practical outcome of the Congress was the adoption, after much debate, of a revised code of nomenclature. This code will be duly promulgated and until this is the case details cannot be discussed, but we know from the reports of delegates that the advanced innovators in nomenclature were in the minority. General matters of interest occupied the attention of the members during the following days, and Brussels was selected as the place of meeting of the third Congress which will be held in 1910.

Memorial to Banks.—In the preceding paragraphs mention is made of the connection between Jacquin and Sir Joseph Banks. This would be a fitting opportunity to draw the attention of the members who can assist to the fact that a "Fund" for the purpose of erecting a suitable memorial to Banks, who has been fittingly described as the "Father of Australia," has been established. This movement has been set on foot by some of the principal citizens of Sydney, who hope to enlist the sympathy and practical assistance of those who can afford to help to establish a public memorial, in order that Australians can be reminded of the credit due to the beneficent guardian of the interests of Australia in the early days, and an investigator of her vegetation, zoology and material resources. Our indefatigable Hon. Secretary Mr. J. H. Maiden has been appointed Hon. Secretary of the movement; I have had the honour of being appointed Hon. Treasurer, and I would certainly like to have an

opportunity of giving receipts for additional funds to the object. Mr. Maiden informs me that he is at work on a lantern-lecture and also on a popular life of Banks, so that Australians may be readily informed as to the principal occurrences in his useful life, particularly as regards this continent.

Science and Education.—Sir William Huggins, president of the Royal Society of London, in his annual address before vacating the chair, dwelt upon the influence which discoveries of science have had upon the general life and thought of the world, especially during the last 50 years, and the place science should take in general education and in the direction of bringing out and developing the powers and freedom of the individual, under the stimulation of great ideas. To become all that we can attain as individuals, is our most glorious birthright, and only as we realise it, do we become at the same time of great importance to the community. From individual minds are born all great discoveries and revolutions of thought. New ideas may be in the air and more or less present in many minds, but it is always an individual who at last takes the creative step and enriches mankind with the living germ-thought of a new era of opinion. This opinion from a man of the standing of Sir William Huggins is one that ought to be borne in mind by all who can in anyway help in the march of scientific thought. Many will perhaps fail, but others may be the fortunate solvers of problems. We in Australia have had our successes in physical development, why not in other and more glorious investigations? Young men of the greatest ability are with us and take the premier positions in our Universities, and under the able tuition of our professors are exceptionally well favoured; these successful students have the ball at their feet—let them do their

best to leave to posterity a name that will be honoured. One other sentiment Sir William Huggins expresses is:—

"Glorious will be the days when, through a reform of our higher education, every man going up to the Universities will have been from his earliest years under the stimulating power of a personal training in practical elementary science; all his natural powers being brought to a state of high efficiency, and his mind actively proving all things under the vivifying influence of freedom of opinion. Throughout life he will be on the best terms with nature, living a longer life under her protecting care, and through the further disclosures of herself rising successively to higher levels of being and of knowledge."

The sentiments of the whole of the valuable report ought to be embedded in the minds of all who value education and the march of science. Then in speaking of the early education of youth, elementary science, taught with the aid of experiment during a boy's early years, cannot fail to develop the faculty of observation. However keen in vision, the eyes see little without training in observation by the subtle exercise of the mind behind them.

From the humblest weed to the stars in their courses, all nature is a great object lesson for the acquirement of the power of rapid and accurate noting of minute and quickly changing aspects in the simpler methods of scientific observation; it confers upon a man for life the possession of an inexhaustible source of interest and delight, and is of no mean advantage in the keen competition of the intellectual activities of the present day.

NOTES ON SOME PLANTS WHICH IN DRYING STAIN PAPER.

By J. H. MAIDEN, Government Botanist and Director of the Botanic Gardens, Sydney.

[*Read before the Royal Society of N. S. Wales, June 6, 1906.*]

EVERYONE with herbarium experience must have made the observation that some plants stain the papers to which they are attached. Some, indeed, stain so persistently (e.g. *Drosera Whittakeri*) that the colouring matter will penetrate a dozen sheets or more. I have not observed that any botanist has drawn special attention to the matter and do not know that any one has given an explanation of these phenomena. I say phenomena, because the colouring or rather staining may arise from various causes, *e.g.* the presence of a specific colouring matter in the root or other portion of the plant, or the formation of a colouring matter by oxidisation or other chemical change. The subject is of course one for a chemist, who will subject the paper itself to examination.

It will be observed that the plants, in many cases, leave sharp photographic impressions on the paper. The phenomena arise from an emanation,—a dry distillation possibly. It is proper to point out that herbarium specimens in the National Herbarium, Sydney, are protected from insect ravages by means of naphthaline. No bichloride of mercury is used, but most plants are placed in a bisulphide of carbon chamber before they are placed in the herbarium boxes.

Most of the stains appear to be purplish, of varying intensity; the remainder are mostly greys and browns. The drying black of plants which do not stain is a cognate

matter which must not be confused with the subject of staining. Many saprophytes and root parasites dry black, e.g. *Monotropa* (Monotropaceæ), *Gerardia* (Scrophulariaceæ), *Comandra* (Santalaceæ). Some *Veronicas*, apparently not root-parasitic dry black, as also do some *Utricularias*. In *Zygophyllum* there is some stain, but this apparently emanates from the juice only of the succulent plant, and this belongs to a different class of phenomena.

I submit to you a list of a few plants (arranged in natural orders alphabetically) which I have observed as having stained paper in my own herbarium. The list is too small for me to deduce much as regards botanical relationships; it may be added to as search in this and other large herbaria will undoubtedly being forth many additional instances.

BIXACEÆ.

Scolopia Gerrardi, Harv. (South Africa).

Oncoba spinosa, Forsk. (Arabia).

Azara microphylla, Hook. (Chili).

These plants, from widely different countries, produce a greenish-grey, greasy looking stain, the *Scolopia* and the *Azara* very abundantly, the *Oncoba* to a less extent.

BORAGINACEÆ.

Alkanna tinctoria, Tausch.

The root produces a purple stain, the well known alkanet.

COMPOSITÆ.

Helichrysum baccharoides, F.v.M., Australia.

The whole plant produces a red to purple blush.

CONVOLVULACEÆ.

Ipomœa heterophylla, R.Br.

The young leafy tips of this Australian plant produce a reddish-brown stain.

DROSERACEÆ.

The first reference to the staining power of Australian *Droseras* I can find is as follows[1]:—"These Droseracous plants appear likely to be in some cases of commercial value as dyers' plants. Every part of *D. gigantea* stains paper of a brilliant deep purple; and when fragments are treated with ammonia they yield a clear yellow. The bulbs of *D. erythrorrhiza* and *stolonifera* possess the same property; in these there is a deep scarlet powder secreted by the scales of the bulbs, which is instantly dissolved in ammonia, forming at first an orange-colored fluid of great richness, but it soon changes to the rich purple above mentioned."

Hooker[2] largely follows Lindley in some remarks on *D. stolonifera*, Endl. Later on, Bentham[3] remarks, "Nearly all the species of this section (Ergaleium) dye the paper in which they are preserved a rich carmine or purple colour."

It remained, however, for Prof. E. H. Rennie of Adelaide to examine the colouring matter of this genus. He first extracted two beautiful red colouring matters from the corms,[4] and subsequently submitted these colouring matters to an exhaustive examination.[5]

GENTIANACEÆ.

Gentiana saxosa, Forst., from the Australian Alps, gives a yellowish-brown, but not strong stain.

LOGANIACEÆ.

Logania linifolia, Schlecht. A specimen from the Mallee district, Victoria, stains paper very strongly purplish; the stain actually goes through the paper.

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[1] Appendix to Edwards' *Botanical Register*:—"A sketch of the vegetation of the Swan River Colony," by John Lindley, xxi. (1839).

[2] *Icones Plantarum*, Vol. IV., tab. 389 (1841).

[3] *Flora Australiensis*, II., 462.

[4] *Journ. Chem. Soc.*, April 1887.

[5] "The colouring matter of *Drosera Whittakeri*," *Journ. Chem. Soc.*, LXIII. 1083 (1893).

L. ovata, R. Br. and *L. longifolia*, R. Br., also Australian plants, likewise exhibit marked stains.

Strychnos psilosperma, F.v.M., N. S. Wales and Queensland, affords a purplish stain, not so intense as *Logania*.

OLEACEÆ.

Jasminum simplicifolium, Forst. Specimens from New South Wales, and Lord Howe Island exhibit a greasy-looking grey stain.

MYRTACEÆ.

Some species of *Eucalyptus* exhibit a greyish stain, which does not appear to be an oil stain. Instances are *E. virgata*, Sieb., and its variety *obtusiflora;* also *E. Luehmanniana*, F.v.M.

POLYGALACEÆ.

Comesperma retusum, Labill., *C. sylvestre*, Lindl., and *C. ericinum*, DC., stain the paper purplish. This tends to confirm the close affinity between these three Eastern Australian species, already ascertained on morphological grounds.

The stain is also seen in *C. flavum*, DC., and *C. calymega*, Labill., two Western Australian species. The stain is of considerable persistence, it being well marked in Dr. Leichhardt's specimens collected in 1843.

The stain is most marked in *C. retusum* so far as my specimens go. I have also observed that in some specimens (e.g., *C. ericinum)* the purplish stain is succeeded by a dull brown one. This opens the enquiry as to how long the purple stain persists as such and when it changes colour in the cases in which it appears to change with age.

RANUNCULACEÆ.

Clematis pubescens, Huegel, a Western Australian species affords a purplish-brown stain which I notice in no other species.

RHAMNACEÆ.

Alphitonia excelsa, Reissek. A well marked brown stain is observable in specimens from the Kurrajong, N.S. Wales. I do not notice it in specimens from other localities. This may be connected with the colouring matter surrounding the seeds, but the pigment which has made such a marked photographic representation of the included plant must be somewhat volatile.

SAMYDACEÆ.

Homalium rufescens, Benth., a Natal plant, exhibits a grey, not abundant, stain.

SANTALACEÆ.

Fusanus persicarius, R. Br., and *F. acuminatus*, DC. (Quandong), both Australian plants, show a profuse brown stain. *Fusanus* is, according to some botanists, congeneric with *Santalum*. I do not notice the stains in any species of *Santalum* (as recognised by Bentham).

SCROPHULARIACEÆ.

The *Veronicas* are very interesting in this connection, affording a dark purplish stain. This is seen in Australian species including *V. formosa*, R. Br., *V. nivea*, Lindl., *V. arenaria*, Cunn. Amongst New Zealand species we have *V. vernicosa*, Hook. f., *V. loganioides*, Armstrong, *V. Lyalli*, Hook. f., and *V. Traversi*, Hook. f. In European species I have noticed it in *V. fruticulosa*, Linn. (very abundant); *V. alpina*, Linn.; *V. serpyllifolia*, Linn. (England); *V. saxatilis*, Jacq. (Switzerland).

VERBENACEÆ.

Lippia nodiflora, Linn. I notice a stain in one specimen from Byron Bay, N. S. Wales, but not in specimens from other parts of the world.

* * * *

I have taken no cognizance of Cryptogams, but Mr. Richard Helms, a member of our Society, has obligingly exhibited some species of *Hymenophyllum*, and has furnished the following notes on them:—"There are three species of New Zealand ferns known to me which stain the drying paper. These are *Hymenophyllum polyanthos*, *H. villosum* and *H. bivalve*.

"There is no difficulty with ordinary care to dry the filmy ferns in their natural colours, and each of these mentioned are no exception. *H. polyanthos* sometimes develops fronds to 7 inches (without the stalk) which are of a dense dark green, and show the venation indistinctly, making when first dried exceptionally handsome specimens. Soon after getting perfectly dry this fern develops a peculiar, rather strong odour, of which I do not know anything similar. It is however not unpleasant, although neither exactly pleasant. The strength of this odour increases for a considerable time and then it gradually diminishes, yet lasting for many years. My specimens collected upwards of twenty years ago still retain it slightly. If ever so carefully kept in a perfectly dry state and excluded from moisture variations in the atmosphere, this fern will become discoloured in often less than a month after first being dried, getting soon quite brown. At this time it begins to stain the paper. The stain like the frond brown is undoubtedly of an oily nature, and soon will penetrate a sheet of tissue paper leaving on both sides of it a perfect impression, which may gradually penetrate a number of layers of even thicker paper.

"*H. villosum* is a mountain species occurring from 2,500 to 5,000 feet. It is in my opinion purely a very characteristic variety of *H. polyanthos*. It is not of the dark even green colours as this fern, but when first dried rather faintly streaky and showing the venation distinctly. Its

fronds are generally not over $2\frac{1}{2}$ to 3 inches long, excluding the fine stalk which varies in length according to situation. It discolours in a similar manner as *H. polyanthos* and stains the paper likewise with an oily impression. The peculiar odour is however not so strong as with *H. polyanthos*. Distinct differences may be observed in these two ferns, but the peculiar odour as well as the oily exudation common to both characterises them as mere varieties of the same species.

"*H. bivalve* can also not be keep green for many months after preparation. It dries a peculiar delicate green with a faint milky hue and discolours to a pale brown in a few months. It does not develop any peculiar odour after being dried, and does not always stain the paper and generally only faintly when it does. The stain however looks oily."

THE TESTING OF BUILDING MATERIALS ON ABRASION BY THE SAND BLAST APPARATUS.

By H. BURCHARTZ, Mitarbeiter des Königlichen Materialprüfungsamtes für Gross Lichterfelde, (Germany).

(Communicated by Prof. W. H. WARREN, M. Inst. C.E.)

[With Plate I.]

[*Read before the Royal Society of N. S. Wales, July 4, 1906.*]

IT is very important to select for building purposes the best materials, more especially if they are used for paving roads and sidewalks, or for covering floors. In addition to the price, the durability of the material must receive due consideration, but it is not so easy to find out a method for testing the wearing qualities, or the resistance to abrasion of materials which will give satisfactory and reliable results

in a comparatively short time. While it is true that one can pave small tracts of a street, etc., with various materials and expose them to the traffic, which would be the best method of determining the resisting force against the influence of mechanical wear, or of the atmosphere, such practical experiments often last several years before the question is definitely decided as to which is the most durable and the cheapest material. No modern community can afford to wait such a long time.

It is most desirable to be able to determine the relative values of different materials for paving and similar purposes in a comparatively short time. However, the method generally used is the abrasion tests proposed by Bauschinger, which consists in grinding specimens of material on cast iron discs with corundum, or the materials are treated in tumbling cylinders, (rattlers), with or without steel balls. Neither of these methods gives a reliable result. The small parts of the material under trial are separated in the grinding process and increase the wearing out; on the other hand, they reduce the effect of the shocks in the rattler by filling the interstices of the material. Again, as the grinding material itself is used up it is impossible to prevent the same grains being used repeatedly, thus changing their shape and effect, and with soft elastic materials the hard grains of the grinding powder partly penetrate the test piece, thus reducing the grinding effect; the grains now rub each other instead of the surface of the specimen, as this is protected by the grains fixed in it. In consequence of the defects of this method of grinding, the results obtained do not give a true guide to the behaviour of the materials under practical conditions.

A new method of treating the materials, by which the difficulties and errors of the methods now in use are avoided, which moreover possesses the great advantage that the

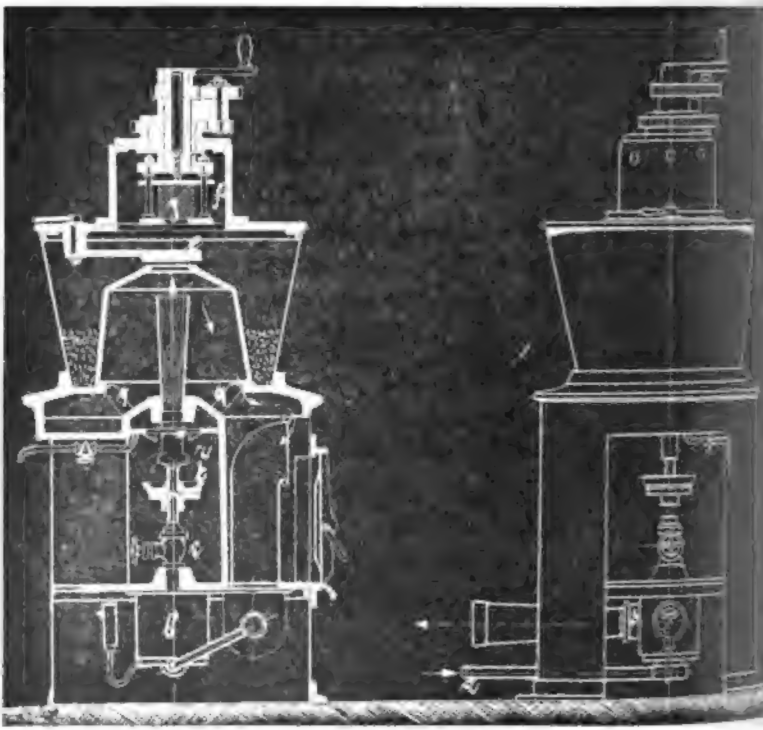
grain producing the grinding acts independently of its bearer, and that each grain touches only once, is demonstrated by the test with the sand-blast. The effect of the sand-blast is well known by the examples offered by nature, and by the various uses of this medium in some industries.

What can be effected by the grinding influence of the sand blown by the wind during centuries is shown, for instance, by the renowned pyramid of Ghizeh; and it can be seen frequently how the dust and sand particles, in a few years, wear out and round off the edges and outstanding parts of buildings. This slow action of the natural sand-blast is imitated in a much higher degree by the artificial sand-blast employed for making dim glass, and cleaning the surface scales of rolled iron.

The sand blast apparatus used for industrial purposes has undergone some changes in order to use it for testing building materials. Such an apparatus in use for abrasion tests in the Royal Institute for testing materials at Gr. Lichterfelde (Germany), is shown in the annexed figure. The working of this apparatus and its effect may be shortly described as follows :—From the sand chamber *n* the sand falls through small tubes *q* on to the plate *a* and thence by small openings into a slit where it is raised by the steam and blown upwards against the piece under test. The steam entering through the pipe is dried in the cylinder *b*. To shut off the steam from the apparatus a valve is inserted in the steam pipe (this valve is not shown on the drawing). Another valve is placed at *c* and must be closed for some minutes before using the apparatus in order to heat the sand, as otherwise it would become wet by condensation of the steam; *r* is a valve for shutting off the sand. The

[1] Gary—Versuche mit dem Sandstrahlgeblase. Mitteilungen aus dem Kgl. Materialprüfungsant, Gr. Lichterfelde, 1904, Heft 3, S. 103, ff. Verlag J. Springer, Berlin.

steam and the dust from the sand being raised by the steam exhauster d; dry sand only is thrown against the specimen. The slide e allows the immediate stoppage of the sand stream. The test piece g is fixed in the frame f and is moved over the sand blast by turning the handle by means



A new apparatus for testing building materials on abrasion. Scale 1 : 10.

of a planet driving gear. Under the sample is placed a sheet iron templet with a round opening of 6 c/m.=(2·4 inches) diameter, and the sand blast makes a recess in the material only on this area of 28 sq. c/m. = (4·34 sq. inches). This recess shows the quality and the characteristic qualities of the material, and the more or less homogeneity of

the different parts, the finer or coarser grain, the uniformity or the irregularity of the wearing out, and as a result whether the material or its constituents are of equal or unequal hardness. It shows the thickness of the coloured layer of burned plates, and of the fine grained covering of concrete plates, as well as the fibrous structure of the various kinds of wood.

All these effects of the sand blast on various materials will be clearly seen from the accompanying photographs. These peculiarities and characteristics of materials are not shown by the grinding or rattling process. By treating materials on a Bauschinger grinding disc a flat surface only is obtained. Some results obtained in the Prussian Testing Laboratory, mentioned above, on abrasion tests made with different materials on the Bauschinger machine, and also by means of the sand blast apparatus are given in Table I. The data given by these results sufficiently prove that the new method described above is most suitable for testing road and floor materials, as it gives reliable information on their quality and on their resistance to wear and abrasion in practical use. At the same time the test under the sand blast gives valuable suggestions as to the possibility of protecting building materials.

The duration of the exposure to the sand blast has been fixed at two minutes after many experiments, the steam gauge indicating 2 atms. pressure, or 44 lbs. per sq. inch. This short time suffices to get a good summary of the structure of the materials tested and their resisting force. The sand used in the Prussian testing institute is a natural quartz sand of fine and nearly round grains, obtained by washing and drying the original sand, and sieving the same on a sieve with 120 meshes per sq. c/m., or about 784 meshes per sq. inch (28 meshes per lineal inch). It is the waste of the manufacturing of the German standard sand

used for testing Portland Cement, the grains of which pass the sieve of 60 meshes and are retained on the sieve with 120 meshes per sq. cm.

The dried specimens of material (*a*) size $7 \times 7{\cdot}1$ cm. ($2{\cdot}8 \times 2{\cdot}8$ inches) = 50 sq. cm. or 7·75 sq. inches area, are weighed before and after the exposure to the sand blast; also the weight of volume (b), that is the weight is determined (in grammes of the unit of volume of the material; including interstices r (in gcm.)

$$\text{The value of, } \frac{\text{Loss of weight in grammes}}{\text{Weight of volume } r \text{ in grammes}}$$

gives figure expressing the resistance of the material to abrasion, and may be used in comparing the value of different materials.

The sand blast apparatus is built by Alfred Gutmann, Actiengesellschaft in Ottensen near Hamburg, Germany).

(*a*) The specimens are either cut out of the materials by means of diamond saws, or formed in moulds if the material is made out of a plastic mass like mortar.

(*b*) The weight of volume is not to be confounded with specific gravity, that is the weight (in grammes) of the unit of volume of the material *without* interstices (in ccm.)

$$\text{The value of } \frac{\text{Weight of volume } r}{\text{Specific gravity } s} = d$$

The difference :—$1 - d = u$; the contents of the interstices, or the porosity.

RESULTS OF TESTS MADE WITH PAVING MATERIALS AND FLOOR COVERINGS ON THE BAUSCHINGER MACHINE AND THE SAND BLAST APPARATUS.

Name and Origin of the Material.	Weight of Volume(r) Gms. per ccm.	ABRASION. Area Treated.		Loss of Material (Average of Two Tests.					Average compressive strength in pounds per square inch.
				Tested on Bauschinger Machine		Tested on Sand Blast Apparatus.			
		Bauschinger machine Sq. cm.	Sand blast apparatus, Sq. cm.	Ccm.	Reduced to the unit of area ccm. per sq. cm.	Gms.	Ccm.	Reduced to the unit of area ccm. per sq. cm.	
Granite, Malmo	2·615	50	28	5·1	0·10	6·91	2·64	0·09	35500
Porphyry, Hopeleben	2·444	50	28	8·5	0 17	8·14	3·29	0·12	27970
Trap, Hunswinkle	2·605	50	28	12 4	0·25	11·07	4·24	0·15	41010
Senneslate, Sennes	2·679	50	28	29 7	0 59	21·49	8 02	0·28	11730
Sandstone, Obersulbach	2·214	50	28	42·5	0 85	48·41	21·87	0·77	8000
Limestone, Gross Uigenore	2·063	50	28	102 0	2·04	73·54	35·65	1·26	3030
Clay plates	2·432	50	28	4·1	0·08	4·06	1·66	0·06	
Clinker plates	2·126	50	28	7·4	0·15	11·47	5·39	0·19	
Paving clinkers	2·146	50	28	13·7	0·26	9·64	4·49	0·16	
Blast furnace slag, Bochum	2·967	50	28	12 7	0·25	10·07	7·39	0·12	
Blast furnace slag, Aplerbeck	2·717	50	28	14 4	0·29	11·40	4·30	0·15	30430
Granitoid plates, 'Comet'...	2·419	50	28	12·4	0 25	11·05	4 57	0·16	26130
Cement (concrete) plates	1·992	46·4	28	27·7	0 56	14 76	7·41	0·26	
Pine	0·580	50	28	5·1	0·10	3·07	5·30	0 67	
Red Pine	0·448	50	28	9·5	0·19	2·28	5·10	0 10	
Red Beech	...	...	28	...	...	1·9	The weight of volume is		
White Beech...	...	...	28	...	...	2 7	not determined for these 4		
Oak	...	...	28	...	...	2 0	materials, therefore the loss		
Pine	...	...	28	...	...	1·6	cannot be calculated.		
Linoleum (A)	1·158	50	28	1 47	0·029	0 68	0·59	0·021	
Linoleum (B)	1·131	50	28	1·77	0 035	0 75	0 66	0 024	
A new floor covering	1·598	50	28	20·4	0·41	14·30	8·95	0·32	
Floor covering, "Hygiena"	1·328	...	28	...	...	1·06	0·80	0·08	

VITIS OPACA, F.v.M., AND A CHEMICAL INVESTIGATION OF ITS ENLARGED ROOTSTOCK (TUBER).

By RICHARD T. BAKER, F.L.S., Curator, and HENRY G. SMITH, F.C.S., Assistant Curator, Technological Museum, Sydney.

[With Plates II., III.]

[*Read before the Royal Society of N. S. Wales, August 1, 1906.*]

OUR attention was first drawn to this subject by Mr. B. E. Sampson, Superior Public School, Tamworth, who in June, 1905, sent to the Museum some very fine specimens of 'tubers' from the roots of a Native Grape, and which were exhibited the same month at the Linnean Society of New South Wales. Specimens of the so-called 'tuber' were afterwards received, attached to a whole plant bearing inflorescence and fruits and from which the species was determined as *Vitis opaca*, F. v. M.

Investigation also proved that of all the species of *Vitis* recorded by Bentham and Mueller in the "Flora Australiensis," not one possesses so great a leaf variation as *V. opaca*, and the leaf variation is so great that it is doubtful whether its description would not almost cover that of *V. angustissima*, F. v. M., a West Australian species, which however has perhaps a distinct inflorescence from that of *V. opaca*. Bentham's description of the leaves of *V. opaca*, F. v. M.,[1] covers a fair amount of latitude of morphological variation, but the systematic material examined by us shows that this species has a greater leaf variation than that of the material he examined. Under these circumstances we now submit the following amended description of the morphology of the leaf of *V. opaca*.

[1] B. Fl., Vol. I., p. 450,

"Leaflets 5 to 3 rarely 4, up to 5 inches long, linear, cuneate, elliptical, oblong, obovate, narrow lanceolate to full lanceolate, occasionally irregularly toothed or crenate, narrowed at the base into either a long or very short petiolule, or even sessile; membranous, dull or not shining, finely veined, the underside of the leaves paler than the upper."

A specimen obtained by Mr. Carne, F.G.S., Assistant Goverment Geologist, from Mount Dangar, Goulburn River, N. S. Wales, has one solitary fair sized leaf which is deltoid in shape, the base being quite straight and the lateral sides below the middle lobed or irregularly toothed.

Baron von Mueller in his Fragmenta, Vol. v., p. 210, mentions that *V. opaca* produces from 8 – 10 tubers weighing from 20 – 25 lbs., and Dr. Woolls is also mentioned *(loc. cit.)* as recording tubers in connection with *V. clematidea*, F. v. M.

It would appear from data published concerning the edible character of these "tubers" that it was not unknown to the autochthonous tribes of Queensland, for Dr. Roth records that the tubers of *V. trifolia* are roasted and used for food, and of *V. clematidea* that the roots are eaten after being beaten on stones and then roasted. Thozet states that the "yams" as he calls them, of *V. opaca*, the subject of this paper, are eaten without any preparation.

Chemistry—The tuber taken for analysis weighed 2 lbs. and was in quite a fresh state. It had a diameter of 95 mm. and a length of 190 mm. Externally it had much the appearance of a large potato, and when cut had an odour which also resembled that of the potato. It was covered externally with a thin brown, papery coating. In transverse section it was at first light in colour, but soon became of a pinkish tint when exposed to the air. The juice on

the cut face was not opaque, was quite mucilaginous in appearance, and could be readily drawn out into threads. The 'tuber' as can be seen from the photograph was formed of concentric rings from the centre to the outside, some of these rings were darker in colour than others, and altogether the appearance resembled that shown by the annual rings in timber. There were twelve rings in the specimen taken, so that if the rings are annual the tuber would be 12 years old. Radiating from the centre to the exterior were medullary rays, built up with vascular bundles, spiral vessels being very pronounced. A transverse section was composed almost entirely of ordinary cells, together with the spiral vessels of the vascular bundles forming the radiating portions. A very marked feature of a microscopical section was the presence of an abundance of raphides of calcium oxalate, and the 'tubers' of this species form excellent material for the demonstration of raphides in plant substance. Portions were taken from several tubers and they all presented the same appearance. The raphides were in bundles of needles in the cells, and also as isolated needle crystals, radiating in all directions, or parallel. When a portion of the "tuber" was stained with an aqueous solution of rosaniline and afterwards cleared with glycerol, the ligneous portion of the 'tuber' was seen to be restricted almost entirely to the spiral vessels. A portion stained with iodine coloured alone the starch, and had no action whatever on the cell tissue. The starch granules had much the appearance of those of potato starch, but were generally smaller. There appeared to be no regular deposition of the starch in particular cells, and the granules were sparsely distributed through the mass. The amount of starch present could hardly equal one tenth of one per cent., judging from the microscopic determination and the result of the extraction. Inulin could not be detected; it was specially sought for in the aqueous extract at 50 – 60° C.

When the mucilage was removed from the pulverised 'tuber,' by treating with water at 50 – 60° C., the remainder showed the raphides in an excellent manner; the mass appeared to be laced together by them, both in bundles and in single crystals. When thin slices were put into boiling water the substance did not dissolve or break up to any great extent, although it swelled considerably. A portion boiled continuously for four hours, became pinkish-brown in colour, but was then as hard and as uninviting as a food material as when first cut. The liquid was quite acid to test paper, and contained a reducing sugar. Thin pieces of the tuber were entirely soluble in concentrated sulphuric acid on gently warming, and without much darkening. On the addition of water and boiling some time, a considerable amount of reducing sugars had been formed.

100 grams of the tuber were taken and which was in as fresh a state as possible; the outer portions were removed and the remainder cut into small pieces and ground into a pulp in a mortar. Water was added, and the whole stood over night, it was then heated at 50 - 60° C. for two hours. The liquid was quite mucilaginous and dropped from the rod in strings. It was squeezed through cloth, as it was impossible to filter it; a considerable amount had apparently gone into semi-solution. The residue was repeatedly heated at 50 – 60° C. in a fresh supply of water, squeezing through the cloth between each addition until 600 cc. had been obtained, and the extraction was thought to be complete. 60 cc. of this solution, when heated until constant at 100 – 105° C. contained 0·2870 gram total solids, equal to 2·870%. The amount of inorganic residue obtained from this on ignition was 0·820 gram equal to 0·820%. This inorganic residue consisted of potassium and magnesium carbonates, a small amount of phosphates and

a little chlorine. Only a very small amount of calcium was detected and this was evidently due to the accidental presence of a few of the raphides which had passed through the cloth. It is thus apparent that the mucilaginous portion of this tuber consisted largely of the organic salts of potassium and magnesium.

On the addition of an equal volume of 90% alcohol to the mucilaginous solution and shaking, a glairy mass separated in strings, which quickly floated to the top of the liquid. The filtrate was quite clear and bright, and on addition of two volumes of alcohol to this, and standing over night only a very small amount had separated; this had the character of a vegetable substance allied to arabin, but was too small in amount to determine with certainty.

Moisture—10 grams of the 'tuber' cut through the centre, were heated at 100–105° C. until constant; the solids weighed 0·4824 gram, so that the water present was 95·176%. A duplicate determination gave 0·4825 gram solids. The dry substance was of a light brown colour and had an odour strongly resembling that of chicory, for which substance it would form a good substitute. It was difficult to prevent any portion becoming brownish when exposed to the air, or to heat, and the aqueous extract soon became slightly coloured, although it was colourless at first. The dried residue when ignited and fully carbonated gave an inorganic residue equal to 1·276% on the tuber.

Ash—As the ash of the above contained alumina (a very unusual thing with plant substances belonging to the Phanerogams), a portion of the 'tuber' was taken from the centre so that no possible contamination could take place. The total ash from this was 24·11% on the dried substance a little less than that of the whole tuber and alumina was present. This material was taken for a quantitive deter-

mination. As none of the exterior portion of the 'tuber' was present, and as the ignition was carried out in platinum, the alumina could not have been of accidental origin. The fully carbonated ash was treated with water and, when thoroughly extracted, 100 cc. of alcohol was added and the whole allowed to stand some time. The filtrate was evaporated down and made up to 100 cc., it did not contain either lime, magnesia, sulphuric or phosphoric acids, but chlorine was present. The insoluble portion contained alumina, lime, magnesia, sulphuric acid, phosphoric acid, and carbon dioxide.

The amount of alumina (Al_2O_3) found was 4·955% on the total ash, only the merest trace of iron was present. Almost the theoretical amount of the platinum salt of potassium was obtained and the K_2O calculated from the total chlorides also agreed, thus indicating that sodium was absent. The percentage amount of CaO in the ash was 20·9; of P_2O_5 2·87; of K_2O 15·74; and of MgO 5·52.

The nitrogen was determined by Kehldahl's method giving 2·847% of nitrogen in the perfectly dried substance, or 0·138% on the 'tuber.' The amount of fats and allied substances soluble in ether was 0·788% on the perfectly dry material, or ·038% of the tuber; a very small amount of a resin was present insoluble in petroleum ether, but this was more readily extracted by alcohol.

Sugar—Only a small amount of substances was extracted by alcohol, and this after removal of the small amount of resin, was found to be largely a crystallised sugar. Special efforts were taken to identify it, and it was determined to be dextrose on the following evidence. A large amount of the pulverised 'tuber' was treated with 90% alcohol for three days. The filtrate, which was colourless, was evaporated to dryness and allowed to stand some time. It was then treated with ether until the resin was dissolved.

The remainder was dissolved in water clarified, and crystallised. Its solution was dextrorotatory, it crystallised well, reduced Fehling's solution readily, had an odour of sugar strongly marked and the osazone melted at 204 – 5° C. Dextrose is the common sugar of the fruit of the vine, and it is thus also shown to occur in the root of this *Vitis.* A quantitative determination of a portion of the aqueous solution of the tuber gave 0·402% of reducing sugars.

Mucilage—The mucilage was determined in the aqueous extract of the original "tuber" at 50 – 60° C. as described above. The extract from 100 grams was precipitated with an equal volume of alcohol, the separated glairy mass removed, washed in alcohol, and dried at 100 – 105° C. 0·6816 gram was obtained equal to 14·13% of the total dried 'tuber,' of this 0·1416 gram represented the fully carbonated ash, or 2·93% of the dried 'tuber.' This ash contained alumina, potassium and magnesium, and a trace of phosphoric acid. Only a small amount of lime was detected and this was due to the few raphides which had passed through the cloth. The mucilage appeared to alter but slightly on long boiling with pure water, and even on boiling with dilute soda, as it separated in an identical manner with an equal volume of alcohol as before treatment; when boiled with very dilute hydrochloric or sulphuric acids it was entirely altered, and on continued boiling reducing sugars were largely formed. When the boiling was only continued sufficiently long that no precipitate took place with two volumes of alcohol, a turbidity was shown; on adding two more volumes of alcohol and on standing, a precipitate was obtained allied to arabin. It is thus seen that the mucilage resembled the ordinary vegetable mucilages soluble in water.

The amount of substance in the dried residue soluble in dilute soda after the water extraction was very small, of no particular interest and was too small to specially determine. Nearly the whole of the substances soluble in dilute hydrochloric acid (0·570%) consisted of calcium oxalate, and the ash (0·339%) was almost entirely calcium carbonate. The amount of cellulose, lignin and allied substances insoluble in the above menstrua was 1·343 gram equal to 27·84% of total dried substance. The small amount of ash from this consisted almost entirely of alumina, indicating that the alumina in the 'tuber' is partly associated with this group of substances.

The above results show that the 'tuber' or enlarged rootstock of this *Vitis* contained:—

Water	95·176	
Fats etc., soluble in ether ...	0·038	contained a resin.
Reducing sugars	0·402	largely dextrose.
Other substances soluble in water	2·468	largely mucilage.
Substances soluble in HCl ...	0·570	largely calcium oxalate
Cellulose, lignin, etc., ...	1·343	contained alumina.
Soluble in NaOH by difference	0·003	
	100·000	

Nitrogen 0·138 per cent.
Carbonated ash 1·276 ,, ,,

There seems to be a somewhat close affinity between the carbohydrates of this 'tuber' and those belonging to the group which includes the true gums. The formation of salts indicates the acid nature of these organic substances, and the alteration products are more in the direction of the sugars than the starches. No active principle was detected at any time during the investigation, and tannins seem also to be absent, as the dried 'tuber,' when boiled in water, gave no reaction for tannin with ferric chloride or

with the usual reagents. From the results of this investigation it appears most probable that the 'tubers' of this species of *Vitis* are simply enlarged root stocks, and as found have comparatively little food value. Cultivation might perhaps improve them somewhat in this respect, but this result is not promising.

We are indebted to Messrs. G. Smith and J. W. Tremain for photographs illustrating the paper.

EXPLANATION OF PLATES.

Fig. 1—"Tuber" with root attachment.

Fig. 2—Section (transverse) through fresh specimen.

Fig. 3—Transverse section through withered specimens. This shows more distinctly than Fig. 2 the medullary rays.

THE AUSTRALIAN MELALEUCAS AND THEIR ESSENTIAL OILS.

By RICHARD T. BAKER, F.L.S., Curator, and HENRY G. SMITH, F.C.S., Assistant Curator, Technological Museum, Sydney.

Part I.

[With Plates IV. - VII.]

[*Read before the Royal Society of N. S. Wales, August 1, 1906.*]

THE *Melaleucas* commonly known as "Tea Trees," and which are distributed throughout the whole continent of Australia, (being found in the dry interior as well as on the mountain ranges and coast districts), may almost be regarded as endemic. *M. Leucadendron*, which is recorded also for the Indian Archipelago, may have escaped from this austral mainland. It was upon material of this latter species that Linnaeus founded the genus in 1767, and since then over 100 species have been described as Australian,

and a few from the Pacific Islands, New Caledonia, Tahiti, etc. With so extensive a geographical distribution, they are necessarily a common object in the bush and are well known to settlers who utilise the timber for such economics as corduroy road making, posts, mallets, etc., the wood being very hard and durable in the ground and under water. The bushes are also extensively used for fascine dyke construction, for which they are more suitable than any other Australian shrub. Some species attain tree size, thus furnishing timber of sufficient dimensions for piles, bridging, wharf-decking, etc. The genus affords little study for the ecological student of botany for the species are as much at home on the dry sandstone country as in moist swampy ground or even the rich humus of the shady gullies.

The Melaleuca oils of Australia apparently differ among themselves in regard to their several constituents and the amount, as do the oils of the Eucalypts, although the genus is not so extensive as Eucalyptus, nor does it contain nearly as many species. It is not to be expected therefore that the constituents will be anything so numerous or so diverse, nor is it considered that the inquiry will be of so interesting a nature, when judged from a botanical and chemical standpoint.

It is the intention during these investigations to apply the same methods in the determination of the Melaleuca species and their oils as has already been done by us in our work on the Eucalypts; and as the results are obtained they will be submitted for publication. It is recommended that similar care be taken in the commercial exploitation of the Melaleucas as is necessary with the Eucalypts. With the Eucalypts, the species name, if authentic, should be a guarantee of the quality of the product, and Melaleucas should not depart from this rule. An indiscriminate

mixing of the leaves of species when used commercially will, of course, give no constant product and detract from the value of any standard which might be formulated.

The following species are investigated:—(1) *M. thymifolia*, Sm. (2) *M. linariifolia*, Sm.

(1). *Melaleuca thymifolia*, Sm., B. Fl. iii. p. 134. "Thyme-leaved Tea Tree."

This was one of the very first Melaleucas described from Australia, the description being published by Smith in the Transactions of the Linnean Society in 1797. It is recorded now from the coast ranges and districts from Southern Queensland to the Blue Mountains and Port Jackson, in the neighbourhood of which it is rather plentiful. It is a small shrub with glabrous leaves and inflorescence; the flowers are purple in colour and quite characteristic of the species, and on this account as well as its valuable oil constituent it is a plant worthy of cultivation. The leaves appear almost veinless but are thickly studded with oil glands, which are scattered irregularly throughout the whole underside of the leaves, but quite absent from the upper or concave side, a provision probably of nature to protect them from the volatilising influence of the sun's rays.

Histology—The transverse vertical section of the leaf blade here given, affords a good type of histological leaf structure. The ventral and dorsal surfaces are covered with only one well defined layer of epidermal rectangular, elongated cells. On the dorsal side and round the edges of the leaf the epidermal cells appear to have the stronger walls, as those on the ventral surface have evidently a thinner wall structure as they break away in cutting.

Stomata are more numerous on the upper surface, giving it a broken appearance in section, and are more clearly shown than generally obtains in most leaf sections. The guard cells are in shape like a pair of anthers and strongly

leveloped, as also are the numerous and spacious air cavities into which they lead, and these form a marked feature of the section.

Below the epidermal cells of the upper surface are found characteristically arranged cells, *i.e.*, the palisade parenchyma, which is composed of a double row of closely opposed columnar cells, whilst below the lower surface one row of palisade cells only occurs. The palisade parenchyma encloses a loosely disposed area of spongy parenchyma.

The position of the midrib and a lateral vein near each edge of the leaf is well brought out in the plate, and each is seen to be constituted by a fibro-vascular bundle consisting of en. endodermic cells, S. scelerenchymatous conjunctive tissue or woody fibre, T. bast, C. cambium, x. xylem.

G. Briosi in his research on the leaves of *Eucalyptus globulus*, Labill., published by Istituto botanico della R. Universiti di Pavia, (1891) names the cells which I make to be similar to en. as collenchymatous, but as no thickening of the walls at the angles could be found, I have preferred to classify those in this instance as endodermic.

Essential Oil—The yield of oil of this species is considerable, no less than 82¾ ounces of oil being obtained from 227 pounds of leaves with terminal branchlets, equal to 2·28%.[1] The material was collected in the month of April in the neighbourhood of Sydney. The crude oil was but slightly coloured, it being yellowish in tint. The rectified oil was colourless. In appearance, odour and taste it differed but slightly from those Eucalyptus oils which are rich in eucalyptol, and which do not contain either the aldehyde aromadendral or the terpene phellan-

[1] J. F. Bailey (Queensland Flora) gives the yield of oil as 13 ounces from 112 pounds, which is only about ¾ per cent. The pronounced oil glands in the leaf of this species, however, indicate a large yield of oil.

drene. The oil was rich in cineol, but neither the terpene pinene nor the terpene phellandrene could definitely be determined in it. The amount of esters was small, the saponification number being only 3·1 with the crude oil, and the higher boiling portion did not become acid when distilled under atmospheric pressure. Volatile aldehydes were present but only in very small amount. The optical activity was but slight and to the right, and the refractive index was comparatively low, indicating that there was hardly any constituent present having a high refractive index. This is also shown by the comparative absence of sesquiterpenes in the third fraction.

The oil of this species has a marked resemblance to the better class Eucalyptus oils, and with present methods it would be difficult to detect its presence in those oils if the rectified oil was used for mixing, or even to decide the identity if it were substituted entirely for the superior Eucalyptus oils. The insolubility in 70% alcohol of the crude oil, together with its forming a turbid solution with excess of 80% alcohol, should be a ready means of detection if this is found to be a constant feature with the crude oil of this species, but this difficulty could easily be got over by rectification.

The crude oil had a specific gravity 0·9134 at 15° C.; a refractive index 1·4665 at 23° C., and a rotation in 100 mm. tube at the same temperature a_D + 2·1°. On rectification only 1% came over below 172° C. (cor.) but 42% distilled between that temperature and 174° C. This fraction had specific gravity 0·9093 at 15° C.; refractive index 1·4657; and a rotation a_D + 3·2°. Between 174 – 183° C., 48% distilled, this had specific gravity 0·9144; refractive index 1·4653; and a rotation a_D + 1·2°. Between 183 – 214° C., 6% distilled, this had specific gravity 0·9192; and refractive index 1·4733. The phosphate method gave 53% of cineol in

the crude oil. The saponification number for the esters was 3·1. A portion of the oil was esterised in the usual way ; 1·999 gram of this required ·0672 gram KOH, thus giving a saponification number = 33·6. This shows the presence of a fair amount of an alcohol and which gave an odour to the saponified oil with a striking resemblance to that of borneol when treated under the same conditions.

The crude oil was not soluble in 10 volumes 70% alcohol, or any quantity below that amount, but the rectified oil, distilling below 183° C., was soluble in 1·3 volumes of 70% alcohol and remained clear with 10 volumes. With ½ volume of 80% alcohol, or with the same amount of 90% alcohol, the crude oil dissolved but became very turbid with 1½ volumes and did not clear again with 10 volumes. The rectified oil was soluble in all proportions with both 80 and 90% alcohol. This peculiarity of solubility in alcohol distinguishes the crude oil of this species of Melaleuca from any of the crude Eucalyptus oils rich in eucalyptol. As the third fraction was soluble in 1·2 volumes 70% alcohol, it appears that the constituent which is insoluble in alcohol is not volatile under ordinary distillation. The crude oil of *M. linariifolia* was soluble in excess of 80% alcohol, thus differing from the oil of this species.

The comparative absence of high boiling constituents in the oil of *M. thymifolia* accounts for the somewhat low specific gravity, and it cannot therefore replace oil of cajuput while the pharmacopoeia standard remains as at present, a standard in which the specific gravity, 0·922 to 0·930 is required. Whether there is now any need for such a standard is questionable.

(2). *Melaleuca linariifolia*, Sm., B. Fl., iii. p. 140. "Tea Tree." This is one of the tallest of tea trees and occurs in the coast district of New South Wales and Southern Queensland.

It is well described by Bentham in the "Flora Australiensis," *(loc. cit.)* and so need not again be described here. A passing reference however might be made to the marginal and lateral veins of the leaf which are distinctly marked, but are not referred to by Bentham *(loc. cit.)* The material upon which this research is founded was obtained at Gosford and was carefully examined in order to correctly establish its botanical identity. There can be no doubt that the chemical results are founded on botanical material true to specific name *i.e.*, *M. linariifolia*, Sm. Like its congener described in this paper it was one of the first Melaleucas recorded, being described by Smith synchronously with that species, *M. thymifolia.* The oil glands are evidently less numerous than those of *M. thymifolia*, but are just as prominent in the lower as the upper surface of the leaf, and the yield of oil is considerably less than in that species.

Histology—The histological characters of the leaves of this species differ in a few particulars from those of *M. thymifolia.* The palisade parenchyma occupies much less of the leaf structure, the difference being occupied by a greater development of spongy tissue. The oil glands, whilst fewer in number, are much larger than those of *M. thymifolia*, an individual gland extending almost from the ventral to the dorsal surface.

Collenchymatous cells which are entirely absent in the sections of *M. thymifolia*, are here very numerous between the midrib and the dorsal epidermis, a character common in the leaves of *Eucalyptus globulus*, Labill.

The large air cavities, so distinctive a feature in the leaves of *M. thymifolia* are almost quite absent in this species, the more numerous and larger air cavities of the spongy parenchyma probably compensating for this deficiency.

We have to acknowledge our indebtedness to Mr. S. J. Johnston, B.Sc., for kindly cutting the section upon which the above histologic remarks are based.

Essential Oil—The yield of oil obtained from the leaves with terminal branchlets of this tree was 1·214%, 260 pounds of material giving 50½ ounces of oil.[1]

The material was collected at Gosford, a few miles north of Sydney, and in the month of September. The crude oil was pale yellow it being of a light lemon tint, and had a turpentine-like odour which was much more strongly marked than with the oil of *M. thymifolia.* The rectified oil was colourless. The cineol content was low; phellandrene could not be detected, nor was evidence obtained of the presence of pinene. The higher boiling portion contained a sesquiterpene which in its colour reaction with bromine (a few drops dissolved in acetic acid and the fumes of bromine passed into the liquid, a violet colour at once forms which falls through the liquid, the whole becoming deep violet changing to indigo blue after some time), correspond to the sesquiterpene of Eucalyptus oils. Volatile aldehydes were present in the first few drops distilling but the amount was very small. The optical activity was slight and to the right, and the refractive index higher than with the oil of *M. thymifolia;* this was due to the larger amount of high boiling constituents present. The oil of this species is largely a terpene one, but an alcohol was present which evidently corresponded with that occurring in the oil of *M. thymifolia.*

The crude oil had a specific gravity 0·9129 at 15° C., a refractive index 1·4741 at 22° C., and a rotation in 100 mm. tube a_D + 2·5°. On rectification only 1 cc. distilled below 172° C., (cor.) but between 172–175° C. 17 cc. distilled.

[1] In the *Technologist,* Vol. III and other places, the yield is given as about 1·5 per cent.

This fraction had specific gravity 0·8976; refractive index 1·4681; and rotation $a_D + 3·0°$. Between 175 – 183° C., 52% distilled, this had specific gravity 0·9003; refractive index 1·4692, and rotation $a_D + 2·9°$. Between 183 – 250° C., 23% distilled, this had specific gravity 0·9136; refractive index 1·476; and rotation $a_D + 4·4°$. Between 250 – 258° C., 4% distilled, this consisted largely of the sesquiterpene; it had specific gravity 0·9233; and refractive index 1.5011. It was distinctly acid, thus showing the presence of an ester. By the phosphate method the crude oil contained 16% of cineol. The saponification number for the esters in the crude oil was 6·4.

A portion of the oil was esterised; 2·0134 grams of this required 0·0812 gram potash, saponification number = 40·3. The amount of the alcohol in the oil of this species is thus a little more than with that of *M. thymifolia.* The crude oil was insoluble in 10 volumes 70% alcohol. It was soluble in 1 volume 80% alcohol and was only very slightly turbid with 10 volumes.

Explanation of Plates.

Transverse Sections of Leaves.

Melaleuca thymifolia.

Fig. 1—Shows the irregular occurrence of three oil glands in the leaf tissue.

Fig. 2—Shows oil glands in a different position to those in fig. 1 and also the large number of air cavities on the ventral surface. The guard cells are also very clearly seen.

Fig. 3—This section contains two large oil glands.

Fig. 4—Here only one small oil gland is seen in that portion of the leaf sectioned; the air cavities are very numerous.

Figs. 1 to 4 are all magnified 50 diameters.

Fig. 9—An enlarged portion of the edge of a leaf blade of *M. thymifolia*, × 250.

Fig. 10—Rough sketch of Fig. 9, × 250. (*a*) Epidermic cells. (*b*) Palisade parenchyma. (*c*) Spongy parenchyma. (*d*) Vascular

bundle. (*e*) Air cavity. (*f*) Guard cells of stoma. (*g*) Oil gland.

Fig. 11—Rough sketch, central vascular bundle × 250. (*e*) Endodermic cells. (*s*) Sheath of sclerenchymatous conjunctive tissue or wood fibre. (*t*) Sieve tube of the bast, phloem. (*c*) Cambium. (*x*) Xylem.

Melaleuca linariifolia.

Fig. 5—This shows the leaf structure of this species, and the large size of the oil glands.

Fig. 6—Only one gland is sectioned in this portion of the leaf blade.

Fig. 7.—A small oil gland is shown near the central vascular bundle.

Fig. 8—No oil glands shown.

Figs. 5 to 8 are all magnified 70 diameters.

PORT SYDNEY.

By Lawrence Hargrave.

[With Plate VIII.]

[*Read before the Royal Society of N. S. Wales, September 5, 1906.*]

Without preamble I place before you the following statements as being axiomatic; and the plan and sections annexed as sufficient for any patriotic New South Walesman to thoroughly grasp the situation and see that the railway and eastern quay of Port Sydney are wanted by the city, now ; and the rest of the work at an early date by the State and the continent.

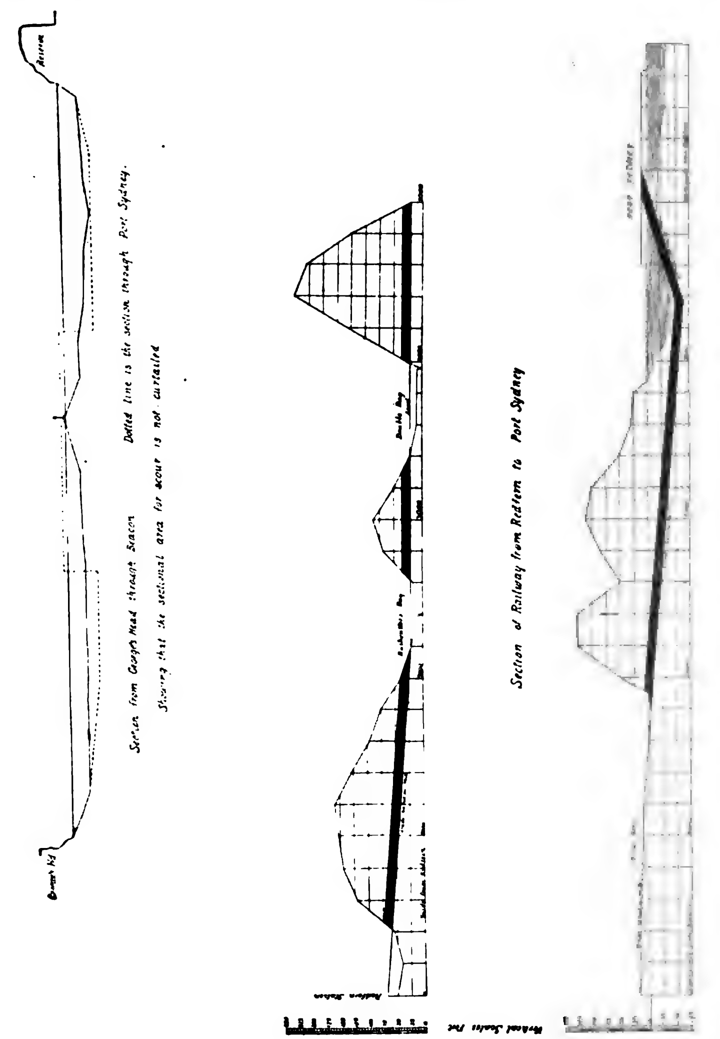
1. The wharfage accommodation of Sydney is inadequate to the immediate future requirements of the State.
2. That lengthening and dredging existing wharves and berths in sites tortuous of approach and already crowded by ferries will only increase the congestion.

3. That an area of at least 147 acres with soundings of 5 fathoms and under, clear of the fairway, is available at the Sow and Pigs shoal for the construction of Port Sydney, without the payment of a penny for resumption or compensation.
4. That eight thousand yards of quay can be placed thereon as shown in plan.
5. That there is ample room to turn for vessels of 1,000 feet in length drawing 40 feet of water.
6. That the sectional area for scour being unaltered, no complications with the holders of riparian rights can ensue.
7. That with our present knowledge of subways, from the Thames tunnel to date, the one shown on the plan presents no difficulties.
8. That there is no obstruction to the fairway while the work is in progress.
9. That the whole of the work is well within the scope of local contractors.
10. That the Panama Canal must make Sydney one of the most important seaports in the Pacific, if we make it easily accessible to existing shipping.

The railway shown is remarkable for leaving city property untouched, except at Gipps and Barcom Streets. The grade shown as 158 feet per mile, becomes 52 feet per mile if the line terminates on the western quay instead of the eastern. I have purposely omitted detail of construction, because any staff of engineers will review known methods and evolve better ones, but of course I have my views on the best course of procedure.

Description of Plan and Sections.—Plan shows continuation of railway from Redfern Station crossing a bridge over Elizabeth Street north of Albion Street to tunnel from

Gipps Street to Barcom Street near the Public School, thence through Chinese gardens to near the junction of Glenmore Road and New South Head Road to tunnel under Darling Point from west side of Glenmore Road to east side of Lower Ocean Street, thence through village of Double Bay



to tunnel under Bellevue Hill from creek at Double Bay to scrubland at Rose Bay, thence across low land and scattered houses to north-east side of Lyne Park, where down grade to Vaucluse Tunnel commences: this tunnel begins near "Tivoli" and ends on the east or west quay of Port Sydney. A shaft at Bottle and Glass would hasten the work by providing two extra working faces for Vaucluse tunnel. The section of the railway shows on an exaggerated scale the tunnel work and grades.

The section from George's Head through Sow and Pigs beacon to the Military Reserve at South Head is taken from the Admiralty Chart. The dotted section on the same line shows the dredged levels through the east and west channels and the position of Port Sydney therein, and it is obvious that the cross section of water is not reduced in area but its form improved for scouring purposes.

A Discussion followed the reading of the above paper in which Messrs. G. H. HALLIGAN, R. V. HODGSON, Dr. F. H. QUAIFE and Mr. T. H. HOUGHTON took part.

Mr. HARGRAVE replied as follows:—Mr. HODGSON mentioned the great cost of carting goods to and from the quays. There is no carting about the job, only six miles extra rail transit and the trucks are alongside the ships. Some one asked about the cost of the work. I have made no estimate, but whatever it is, it will be small compared with the advantage of securing the over-sea traffic of the continent of Australia. The prize is equally within the grasp of the Queenslanders: but their works include a standard gauge railway from the South Australian boundary to Moreton Bay. Another speaker said the site was exposed to attack in case of war. I do not see that a few shells in the concrete would do much damage, nor why Port Sydney should draw the fire when our beautiful public buildings are within sight and range: besides,

anyone at all acquainted with the present state of aeronautics knows that matters will be settled by "bolts from the blue."

As to exposure to storms. Our dangerous weather comes from S.E. to N.E. The S.E. seas run on to Manly and Dobroyd; the N.E. seas are broken by North Head. The visible horizon of Port Sydney is E. by N. to N.E. by E., and seas from this point are more or less broken up by North Head and South Reef; and taking a free estimate of stormy weather, we may safely say that during a fortnight per annum the outside berths of Port Sydney would be what shellbacks call uneasy, the other 6,000 yards are in a pond. The exposure is nothing compared to Plymouth breakwater that shows a mile front to a S.W. Atlantic gale.

Lessons may be learnt from London; once Londoners embarked in galliots at the Fleet Ditch, now they enjoy the facilities of Tilbury. At Dover the rise and fall of the tide makes a vast difference in the quantity of work when we compare it with our insignificant five or six feet. Cherbourg and Colombo are also made ports. Galveston in the Gulf of Mexico has also done a lot of similar work to ours; and then we have the wealth of experience gained and being acquired at New York with subways to profit by.

Dr. Quaife described at length the freezing process for driving subways; it is an excellent method and enables us to penetrate any rubbish. As one of the speakers pointed out, it is delineated by Mr. Norman Selfe for founding the piers of his Great Sydney Bridge. Another speaker said he would prefer to use up-harbour frontages, but picture to yourselves the "*Lusitania*" in Darling Harbour being turned end for end; and besides most of the foreshores are cliffs and you have to carve out the wharf, and

for twenty years' continuous service, was in order that I might be present at that Congress.

It was attended by very eminent men, and took the wise course of not attempting to "settle" certain difficult points, but, bearing in mind the great interest that had been aroused, of remitting important decisions to a second International Congress to be held in Vienna in 1905. It also enunciated the principle of holding an International Congress or Parliament of Botanists thereafter every five years, for the discussion of such matters of nomenclature as might be brought before it. There is therefore now in existence a duly constituted International Tribunal of nomenclature. I have already pointed out,[1] that "the way is gradually being paved for the establishment of a 'Tribunal of Nomenclature' whose decisions no botanist may afford to disregard."

The next Congress is fixed for 1910 at Brussels. In 1903 I published a presidential address[2] dealing with the great question of nomenclature, and ever since the Paris Congress I have been in touch with M. Emile Perrot the General Secretary of the Paris Congress, and Dr. John Briquet of Geneva, the "Rapporteur Général" of the Vienna Congress, voting, as a member of the Paris Congress on certain points remitted for the consideration of members.

Invitation was extended to members of the Paris Congress, and indeed to all botanists, to prepare resolutions and data for consideration of the Vienna Congress, whose members might therefore debate with the fullest knowledge. In consequence, a considerable number of valuable documents were circulated amongst members including the following:—

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[1] Proc. Linn. Soc. N. S. Wales, 1903, p. 687.

[2] "On the principles of botanical nomenclature," Proc. Linn. Soc., N.S. Wales, 1903.

1. "Nomenclaturæ botanicæ Codex brevis Maturus etc." auctore Otto Kuntze, Stuttgart, 1903, 8 vo., pp. lxiv.

"Zweiter Anhang zum Nomenclaturæ Botanicæ Codex brevis Maturus," von Dr. O. Kuntze, pp. lxv. – lxxvi.

Additions aux lois de Nomenclature botanique (code Parisien de 1867) d'après le Codex Emendatus de M. Otto Kuntze (Journal de Botanique, pp. 15, t. xiv., 1900).

Exposé sur les Congrès pour la Nomenclature Botanique, et six propositions pour le Congrès de Paris en 1900," par le Dr. Otto Kuntze, 8 vo. pp. 16 (no date ? 1900).

"Protest gegen die zweite 'Commission internationale de Nomenclature botanique,'" Dr. Otto Kuntze. Allg. Botan. Zeitschr. No. 9, 1902, pp. 4, together with leaflets.

See also "Lexicon generum phanerogamarum, inde ab anno 1737 cum nomenclatura legitima internationali et systemati inter recentia medio," auctore Tom von Post, opus revisum et auctum ab Otto Kuntze, a valuable bibliographical work.

2. "Propositions de changements aux lois de la nomenclature botanique de 1867 . . . par un groupe de botanistes belges et suisses." (15 Janvier, 1904).

3. "Projet de la revision des lois de Nomenclature presenté par la Société Imperiale de Naturalistes de Moscow," 8 vo. pp. 10.

4. "Code of Botanical Nomenclature." In English, French and German. Signed by various representative American botanists. *Bull. Torrey Botanical Club*, 31, 249 - 61, May 1904.

5. "Motion au Congrès international de Botanique, Deuxième Session, Vienne 1905." *Nyt Magazin f. Naturvidenskaberne* B. 42, pp. 217 – 20. Kristiania, 1904. Signed by Drs. N. Wille and V. Wittrock.

6. "Amendments to the Paris Code of Botanical Nomenclature, suggested for the consideration of the Vienna Congress of 1905 by the botanists of the Gray Herbarium, the Cryptogamic Herbarium, and the Botanical Museum of Harvard University," 9th June, 1904. In French, English, and German.

7. "Des diagnoses et de la Nomenclature Mycologiques." Propositions par P. A. Saccardo. *Bull. Soc. bot. ital.*, Fasc. 6, 12. Guigno 1904.

"De diagnostica et nomenclatura mycologica. Admonita quaedam." Auctore P. A. Saccardo. *Ann. Mycol.* ii., No. 2, 1904.

8. "Amendments to the Paris Code of Botanical Nomenclature, suggested for consideration of the Vienna Congress of 1905 by the botanists of the British Museum, and others." 8 vo. pp. 3.

9. "Vorschlag zur Ergänzung der 'Lois de la Nomenclature botanique de 1867' dem in Wien 1905 tagenden Nomenclatur-Kongress zur Annahme empfohlen," von H. Harms. *Notizbl. des Königl. bot. Gartens etc. zu Berlin.* Appendix xiii., 20 Juni, 1904.

10. Motion présenteé au Congrès international de Botanique, Vienne 1905, par Joseph Brunnthaler. *Verhandl. der K. K. Zool. bot. Gesells. in Wien.*, 1904, p. 1. Recommending that the matter of Cryptogamic botany be remitted to the next international botanical congress.

11. "Anträge zur Regelung der botanischen Nomenklatur für den internationalen Botaniker-Kongress, Wien 1905," von Dr. August v. Hayek. *Ibid*, pp. 341 – 351.

12. "Adjonctions au code de Paris de 1867, proposées par quelques botanistes Italiens." Florence, Juin 1904 (In French and Italian) 8vo. pp. 12.

13. "Additions et Modifications aux lois de la Nomenclature botanique de 1867, approvées par les membres de la Société botanique de France," 1904, pp. 12.

14. "Motions Supplementaires présentées au Congrès International de Botanique de Vienne," par P. A. Saccardo, Avellino, Juin 1904, p. 1.

15. "Motion présentée au Congrès international de Botanique de Vienne," par Mr. Ernest Malinvaud, Paris, 25 Juin, 1904, p. 1.

16. "Additions et Modifications aux lois de la Nomenclature botanique de 1867," proposées par M. Georges Rouy, pp. 4.
"Questions de Nomenclature," par M. G. Rouy. *Rev. bot. Syst. et de Géog. bot*, 1 Juill. 1904, pp. 81 – 102.
17. "Observations et propositions présentées au Congrès de Vienne" par B. P. G. Hochreutiner, 26 Juin, 1904 (Supplementary to No. 2, above).

They form a library of information in regard to the principles of nomenclature for careful reference at all times.

The main decisions of the Vienna Congress were soon made known by means of botanical and other scientific journals, and I give references to some [1] of the excellent, though necessarily brief accounts which appeared at the time.

But, although these accounts are based on the reports of eminent botanists, they are all unofficial, and I have the honour to bring under your notice the official document [2] which I received early last month, and which is, probably, the only copy in New South Wales at present.

It is an epoch-making document, and every Australian botanist will require to make himself acquainted with its provisions. He can no more ignore the decisions than can a citizen ignore the laws of his country. This document is an extract from a larger volume [3] which contains a report of the debates which led to the adoption of these International rules of botanical nomenclature.

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[1] For example, *Gard. Chron.*, 1st July, 1905, p. 10; *Journal of Botany*, July 1905, p. 215, (Rendle); *Nature*, 20th July, 1905, p. 272; *Botanical Gazette* (Chicago), July 1905, Reprinted in *Amer. Journ. Pharm.*, Sept. 1905, p. 417; *Park and Cemetery* (Chicago), Sept. 1905, p. 353 (Trelease).

[2] Règles internationales de la Nomenclature botanique adoptées par le Congrès International de Botanique de Vienne 1905 et publiées au nom de la Commission de Rédaction du Congrès par John Briquet, Rapporteur Général." (Verlag von Gustav Fischer in Jena, 1906).

[3] "Actes du Congrès international de Botanique tenu à Vienne (Autriche) 1905." (G. Fischer, Jena).

The document before us is based upon the De Candollean "lois" of 1867, and pages 5—16 are taken up with a synoptical table or "Concordance des Lois de la Nomenclature botanique de 1867 et des Règles et Recommandations de 1905."

Then follow the "International Rules" in three languages, French, English, and German. This is succeeded by a table of *Nomina Conservanda* of the greatest interest to Australians and which must be respected by every Australian botanist. I extract the Australian genera as an appendix. Lastly we have a useful "Index analytique."

Examination of these International Rules shows that the more conservative or moderate botanists have exercised the greatest influence. Personally, whatever the decisions might be, I have always been prepared to respect them. I have discussed the matter with various influential European and American botanists who have been in Sydney during the last three years and who intended to go to Vienna, and who indeed went, and have written to various European and American botanists in the same strain that, while it was very possible that the great distance would prevent Australian botanists from attending the Congress at Vienna, I believed that they would be loyal to its decisions. I believe that to be the case, and my object in reading the present paper is to point out some of the decisions which specially affect us or are of more or less local interest to us and to enjoin my Australian brethren to obtain copies of the International rules and make them their daily guide of botanical practice.

I have no intention of going over the whole of the rules. *Article 2* enunciates "*principles*, *rules* and *recommendations*." I am obliged to extract the article as otherwise I cannot be understood.

"The principles (Art. 1 – 9, 10 – 14 and 15 - 18) are the foundation of the rules and recommendations. The rules (Art. 10 – 58) destined to put in order the nomenclature which the past has bequeathed to us, and to form the basis for the future, are always retroactive: names or forms of nomenclature which are contrary to a rule cannot be maintained. Recommendations bear on secondary points, their object being to ensure for the future a greater uniformity and clearness in nomenclature: names or forms of nomenclature contrary to a recommendation are not a model to copy, but cannot be rejected."

Article 9. "The rules and recommendations of botanical nomenclature apply to all classes of the plant kingdom, reserving special arrangements for fossil plants and non-vascular plants."[1]

Article 14. "The fertilization of one species by another, gives rise to a hybrid *(hybrida)*; that of a modification or subdivision of a species by another modification of the same species gives rise to a half-breed *(mistus, mule* of florists).

Recommendations—1. The arrangement of species in a genus or in a subdivision of a genus is made by means of typographic signs, letters or numerals. Hybrids are arranged after one of the parent species, with the sign × placed before the generic name.

The arrangement of subspecies under a species is made by letters or numerals; that of varieties by the series of Greek letters α, β, γ, etc. Groups below varieties and also half-breeds are indicated by letters, numerals or typographic signs at the author's will."

Article 19. "Botanical nomenclature begins with the *Species Plantarum* of Linnæus, ed. 1 (1753) for all groups of vascular plants. It is agreed to associate genera, the names of which appear in this work, with the descriptions given of them in the *Genera Plantarum* ed. 5 (1754)."

[1] These special arrangements have been reserved for the Congress of 1910. They comprise: 1. Rules bearing on special points in relation to the nature of fossils or the lower plants; 2. Lists of *nomina conservanda* for all divisions of plants other than Phanerogams.

Article 20. "However, to avoid disadvantageous changes in the nomenclature of genera by the strict application of the rules of nomenclature, and especially of the principle of priority in starting from 1753, the rules provide a list of names which must be retained in all cases. These names are by preference those which have come into general use in the fifty years following their publication, or which have been used in monographs and important floristic (floristiques) works up to the year 1890. The list of these names forms an appendix to the rules of Nomenclature."[1]

Article 25, Recommendation v.c. "Not to dedicate genera to persons who are in all respects strangers to botany, or at least to natural science, nor to persons quite unknown."

Recommendation vh. "Not to make names by the combination of two languages (*nomina hybrida).*

Article 26, Recommendation viii. "The specific name should, in general, give some indication of the appearance, the characters, the origin, the history or the properties of the species. If taken from the name of a person, it usually recalls the name of the one who discovered or described it, or was in some way concerned with it."

Recommendation ix. "Names of men and women and also names of countries and localities used as specific names, may be substantives in the genitive (*Clusii, saharæ)* or adjectives (*Clusianus, dahuricus).* It will be well, in the future, to avoid the use of the genitive and the adjectival form of the same name to designate two different species of the same genus (for example *Lysimachia Hemsleyana*, Maxim. (1891) and *L. Hemsleyi*, Franch. (1895)).

Recommendation x. "Specific names begin with a small letter except those which are taken from names of persons (substantives or adjectives) or those which are taken from generic names (substantives or adjectives).

Examples: *Ficus indica, Circaea latetiana, Brassica Napus, Lythrum Hyssopifolia, Aster novibelgii, Malva Tournefortiana, Phyteuma Halleri.*"

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[1] See Appendix p. 87.

I do not see my way to accept[1] these recommendations in full. Names derived from persons should be always written with a capital letter, *e.g.*, *Phyteuma Halleri.*

Names derived from substantive generic names I would recommend also to be written with a capital letter, *e.g.*, *Brassica Napus.*[2] Names derived from adjectival generic names should be written, in my opinion, with a small letter, in spite of the recommendation to the contrary. Thus if we write *Lythrum Hyssopifolia*,[2] as recommended, we must logically write *Acacia Myrtifolia*, *Boronia Ledifolia*, *Ricinocarpus Pinifolius* and numerous other barbarisms. I trust this point will be brought forward at the Brussels Congress of 1910.

Article 26, Recommendation xiv*e*. "Adopt unpublished names found in travellers' notes and herbaria, attributing them to the authors concerned, only when those concerned have approved the publication."[3]

I have in several cases offended against this recommendation, having been a party to the publication of several new varieties under Mueller's name from his herbarium notes. For instance: *Boronia ledifolia*, var *repanda*, F.v.M.[4] It is my intention not to so offend in future.

Recommendation xiv*g*. "Do not name a species after a person who has neither discovered, nor described, nor figured, nor in any way studied it."

Article 31. "Hybrids between species of the same genus, or presumably so, are designated by a formula and, whenever it

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[1] See Art. 2 as to the discretion allowed to botanists in regard to "Recommendations."

[2] These cases are based on Linnæus' recommendation in *Species Plantarum* (1753). I have already discussed this point, *Proc. Linn. Soc., N.S. Wales*, 1903, 704.

[3] I have gone into this matter, in which there have been differences in practice, in *Proc. Linn. Soc. N. S. Wales*, 1903, 698.

[4] *Proc. Linn. Soc. N. S. Wales*, 1904, p. 735.

seems useful or necessary, by a name. The formula consists of the names or specific epithets of the two parents in alphabetical order and connected by the sign ×. When the hybrid is of known experimental origin the formula may be made more precise by the addition of the signs ♀, ♂. The name, which is subject to the same rules as names of species, is distinguished from the latter by absence of an ordinal number and by the sign × before the name.

Examples: × *Salix capreola* = *Salix aurita* × *caprea; Digitalis lutea* ♀ × *purpurea* ♂; *Digitalis lutea* ♂ × *pupurea* ♀."

Article 35. "Publication is effected by the sale or public distribution of printed matter or indelible autographs. Communications of new names at a public meeting, or the placing of names in collections or gardens open to the public, do not constitute publication."

Article 36. "On and after January 1, 1908, the publication of names of new groups will be valid only when they are accompanied by a Latin diagnosis."

A "group" is defined in Article 13, and includes a species.

Article 37. "A species or a subdivision of a species, announced in a work, with a complete specific or varietal name, but without diagnosis or reference to a former description under that name, is not valid. Citation in synonymy or incidental mention of a name is not effective publication, and the same applies to the mention of name on a ticket issued with a dried plant without printed or autographed diagnosis. Plates accompanied with analyses are equivalent to a description; but this applies only to plates published before January 1, 1908."

Article 39. "The date of a name or of a combination of names is that of their effective publication. In the absence of proof to the contrary, the date placed on the work containing the name or combination of names is regarded as correct. On and after January 1st, 1908, the date of publication of the Latin diagnosis only can be taken into account in questions of priority."

Recommendation xix. "To avoid publishing or mentioning in their publications unpublished names which they do not accept, especially if the persons responsible for these names have not formally authorised their publication." See Rec. xiv*e*.

Recommendation xxi. "To give the etymology of new generic names and also of specific names when the meaning of the latter is not obvious."

Recommendation xxiv. "Separate copies should always bear the pagination of the periodical of which they form a part; if desired they may also bear a special pagination."

Article 43, Recommendation xxv (in part). "Authors' names put after names of plants are abbreviated unless they are very short. . . When it is a well established custom to abridge a name in another manner, it is best to conform to it (L. for Linnaeus, DC. for De Candolle, St. Hil. for Saint Hilaire). In publications destined for the general public and in titles it is preferable not to abridge."

In Germany and France it is the custom to write Linné (Linnaeus) with a simple L. or L. f. for his son, not Linn. as in the English habit.

This is not an important matter, but I recommend that the continental practice be followed. Linné is so preeminent in Botany that this privilege of a simple letter can be granted him as a solitary exception; nobody would mistake L. for Lindley or for any other botanist.

Article 50. "No one is authorised to reject, change or modify a name (or combination of names) because it is badly chosen, or disagreeable, or another is preferable or better known, or because of the existence of an earlier homonym which is universally regarded as non-valid, or for any other motive either contestable or of little import. (See also Art. 57)."

I have already dealt with this point.[1]

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[1] *Proc. Linn. Soc. N. S. Wales*, 1903, p. 708.

Article 58. "The rules of botanical nomenclature can only be modified by competent persons at an International Congress convened for the express purpose."

Then as an Appendix we have several recommendations including:—

xxxiv. The metric system only is used in botany for reckoning weights and measures. The foot, inch, line, pound, ounce etc., should be rigorously excluded from scientific language."

xxxvii. Temperatures are expressed in degrees of the centigrade thermometer of Celsius."

Finally, these laws have been adopted by a duly constituted International Botanical Congress and they should be accepted. Australian botanists live under the freest political institutions in the world; if they desire to alter the laws, they proceed, by constitutional means, to bring their desires about. Let the same method be adopted in regard to any of the rules of which they disapprove, but, in the meantime I feel sure that Australian botanists will obey them and obey them loyally.

These rules seem to be a crystallization of common-sense and moderation. No friend of our science can ever contemplate, without regret, the botanical anarchy which has been gaining ground during the last two decades and which the pronouncements of the Vienna Congress will do much to stem. In this connection Dr. John Briquet, the Reporter-General, has laid botanists throughout the world under a great debt of obligation.

It will take us some time to get used to these laws, and therefore mutual forbearance is required. But they are worthy of careful study and of every respect, and I submit them with courtesy and earnestness to all Australian and New Zealand botanists.

APPENDIX.

"Index nominum genericorum utique conservandorum secundum articulum vicesimum regularum nomenclaturæ botanicæ internationalium.

Phanerogamæ (Siphonogamæ)."

(Australiensum.)[1]

Taxaceæ—[2]

Podocarpus L'Hér. ex Pers , Synopsis ii. (1807) 580. [*Nageia*, Gaertn.]

Phyllocladus, L. C. Rich, Conif. (1826) 129, t. 3. [*Podocarpus* Labill.]

Pinaceæ—

Agathis, Salisb. in Trans. Linn. Soc., viii. (1807) 311. [*Dammara*, Lam.]

Potamogetonaceæ—

Cymodocea , Ch. Koenig. in Koenig et Sims, Ann. of Bot. ii. (1805) 96, t. 7. [*Phycagrostis*, O. Ktze].

Gramineæ—

Rottboellia, L. f., Nov. gramin. gen. (1779) 19. [*Manisuris*, L.]

Tragus, [Hall., Hist. stirp. Helvet. ii. (1768) 203]. Scop., Introd. (1777) 73. [*Nazia*, Adans.]

Zoisia, ("Zoysia") Willd. in Neue Schrift. Ges. naturf. Fr. Berlin iii. (1801) 440. [*Osterdamia*, Neck.]

Leersia, Swartz, Prodr. veg. Ind. occ. (1788) 21. [*Homalocenchrus*, Mieg.]

Ehrharta, Thunb. in Vet. Akad. Handl. Stockholm (1779) 216, t. 8. [*Trochera*, L. C. Rich.]

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[1] The original should be referred to in all cases of doubt, as I may have omitted a genus. In this Journ. xxxix., 38, (1905), I undertook to bring under notice the names attached by Mr. Britten to the Banks and Solander plants, and the names which stand can now be readily ascertained by reference to the list which follows.

[2] In this list we have firstly the Family (the term Natural Order is now suppressed), secondly the nomina conservanda with bibliographic references, and thirdly the nomina rejicienda. The change from Natural Orders to Families is so important that it seems desirable to emphasise it. The old term "Natural Order" signified a group of genera; now it means a group of Families; *e.g.*, the Order Glumifloræ includes the Families Gramineæ and Cyperaceæ.

Hierochloe [J. G. Gmel., Fl. sibir. i. (1747) 1001] R. Br., Prodr. (1810) 208. [*Savastana*, Schrank; *Torresia*, Ruiz et Pav.; *Dissarrenum*, Labill.]

Cynodon, L. C. Rich. in Persoon, Synops. i. (1805) 85. [*Capriola*, Adans; *Dactilon*, Vill.; *Fibichia*, Koel.]

Glyceria, R. Br., Prodr. (1810) 179. [*Panicularia*, Fabr.]

Cyperaceæ—

Lipocarpha, R. Br., in Tuckey, Congo (1818) 459. [*Hypaelyptum*, Vahl.]

Fimbristylis, Vahl., Enum. ii. (1806) 285. [*Iria*, L. C. Rich. *Iriha*, O. Ktze.]

Rhynchospora, Vahl., Enum. ii. (1806) 229. [*Triodon*, L. C. Rich.]

Restionaceæ—

Hypolaena, R. Br., Prodr. (1810) 251. [*Calorophus*, Labill.]

Juncaceæ—

Luzula, DC., in Lamarck et De Candolle, Fl. franç. ed. 3, iii. (1805) 158. [*Juncoides*, Adans.]

Liliaceæ—

Thysanotus, R. Br., Prodr. (1810) 282. [*Chlamysporum*, Salisb.]

Cordyline, Comm. ex Juss., Gen. (1789) 41. [*Terminalis*, Rumph.]

Astelia, Banks et Sol. ex R. Brown, Prodr. (1810) 291. [*Funckia*, Willd.]

Iridaceæ—

Libertia, Spreng., Syst. i. (1825) 127. [*Tekel*, Adans.]

Patersonia, R. Br., Prodr. (1810) 303. [*Genosiris*, Labill.]

Orchidaceæ—

Spiranthes, R. C. Rich. in Mém. Mus. Paris iv. (1818) 50. [*Gyrostachis*, Pers; *Ibidium*, Salisb.]

Liparis, L. C. Rich. in Mém. Mus. Paris iv. (1818) 43. [*Leptorkis*, Thou.]

Oberonia, Lindl., Gen. and Spec. Orchid Pl. (1830) 15. [*Iridorkis*, Thou.; *Iridorchis*, Thou.]

Calanthe, R. Br., in Bot. Reg. (1821) sub t. 573. [*Alismorkis* Thou.; *Alismorchis*, Thou.]

Eulophia, R. Br., in Bot. Reg. (1823) t. 686. [*Graphorkis*, Thou.; *Graphorchis*, Thou.]

Dendrobium, Swartz in Nova Acta upsal. vi. (1799) 82 et in Vet. Akad. Nya Handl. xxi. (1800) 244. [*Callista*, Lour.; *Ceraia*, Lour.]

Bulbophyllum, Thou., Hist. pl. Orchid. (1822) Tabl, des espèc. iii. [*Phyllorkis*, Thou.; *Phyllorchis*, Thou.]

Saccolabium, Blume, Bijdr. (1825) 292. [*Gastrochilus*, D. Don.]

Urticaceæ—

Laportea, Gaudich. in Bot. Voy. Freycinet (1826) 498. [*Urticastrum*, Fabr.]

Proteaceæ—

Persoonia, Smith in Trans. Linn. Soc. iv. (1798) 215. [*Linkia*, Cav.]

Isopogon, R. Br., ex Knight, Proteac. (1809) 93 et in Trans. Linn. Soc. x. (1810) 71. [*Atylus*, Salisb.]

Telopea, R. Br., in Trans. Linn. Soc. x. (1810) 197. [*Hylogyne*, Salisb.]

Lomatia, R. Br., in Trans. Linn. Soc. x. (1810) 199. [*Tricondylus*, Salisb.]

Stenocarpus R. Br., in Trans. Linn. Soc. x. (1810) 201. [*Cybele*, Salisb.]

Dryandra, R. Br., in Trans. Linn. Soc., x. (1810) 211 t. 3. [*Josephia*, Salisb.]

Santalaceæ—

Exocarpus, Labill., Voy. i. (1798) 155 t. 14. [*Xylophyllos*, Rumph.; *Xylophylla*, L.]

Polygonaceæ—

Emex, Neck., Elem. ii. (1790) 214. [*Vibo*, Medik.]

Chenopodiaceæ—

Suaeda, Forsk., Fl. aegypt. arab. (1775) 69 t. 18. [*Dondia*, Adans.; *Lerchea*, Rueling]

Portulacaceæ—

Calandrinia, H. B. K., Nov. gen. et spec. vi. (1823) 77 t. 526. [*Cosmia*, Domb. ex Jussieu; *Baitaria*, Ruiz et Pav.]

Caryophyllaceæ—

Spergularia, J. et. C. Presl., Fl. cech. (1819) 94. [*Buda*, Adans; *Tissa*, Adans]

Menispermaceæ—

Cocculus, DC., Syst. i. (1818) 515. [*Cebatha*, Forsk.; *Leaeba*, Forsk.; *Epibaterium*, Forsk.; *Nephroia*, Lour.; *Baumgartia*, Mœnch.; *Androphylax*, Wendl.; *Wendlandia*, Willd.]

Myristicaceæ—

Myristica, [L., Gen. ed. 2 (1742) 524] Rottb. in Act. Univ. Hafn. (1778) 281; L. f., Suppl. (1781) 40. [*Comacum*, Adans; *Aruana*, Burm.]

Lauraceæ—

Litsea, Lam., Encycl. iii. (1789) 574. [*Malapœnna*, Adans: *Glabraria*, L.; *Tomex*, Thunb.]

Cruciferæ—

Capsella; Medik, Pflanzengatt (1792) 85. [*Bursa*, Weber.; *Marsypocarpus*, Neck.]

Malcolmia, R. Br. in Aiton, Hort. Kew. ed. 2, iv. (1812) 121. [*Wilckia*, Scop.]

Capparidaceæ—

Gynandropsis, DC., Prodr. i. (1824) 237. [*Pedicellaria*. Schrank.

Cunoniaceæ—

Weinmannia, L., Syst. ed. 10 (1759) 1005. [*Windmannia*, P. Br.]

Leguminosæ—

Peltophorum, Walp., Rep. i. (1842) 811. [*Baryxylum*, Lour.]

Podalyria, Lam., Illustr ii. (1793) 454, t. 327, f. 3, 4. [*Aphora* Neck.]

Oxylobium, Andrews, Bot. Repos. (1809) t. 492. [*Callistachys*, Vent.]

Tephrosia, Pers., Synops. ii. (1807) 328. [*Cracca*, L.; *Colinil*, Adans.; *Needhamia*, Scop.]

Clianthus, Banks et Soland. ex G. Don, Gen. Hist. ii. (1832) 468. [*Donia*, G. Don]

Desmodium, Desv., Journ. de bot. i. (1813) 122 t. 5. [*Meibomia*, Adans.; *Pleurolobus*, J. St. Hil.]

Dalbergia, L. f, Suppl (1781) 52. [*Amerimnon*, P. Br.; *Ecastaphyllum*, P. Br.; ? *Acouroa*, Aubl.]

Lonchocarpus, H. B. K, Nov. gen. et spec. vi. (1823) 383. [*Clompanus*, Aubl.; *Robina*, Aubl.]

Pongamia, Vent., Jard. Malmaison (1803) 28. [*Galedupa*, Lam.]

Derris, Lour., Fl. cochinch. (1790) 432. [*Salken*, Adans.; *Solori*, Adans.; *Deguelia*, Aubl.; *Cylizoma*, Neck.]

Kennedya, Vent., Jard. Malmaison ii. (1804) 104. [*Caulinia*, Mœnch.]

Mucuna, Adans., Fam. ii. (1763) 325. [*Zoophthalmum*, P. Br.; *Stizolobium*, P. Br.]

Rhynchosia, Lour., Fl. cochinch. (1790) 400. [*Dolicholus*, Medik.]

Rutaceæ—

Acronychia, Forst, Char. gen. (1776) 53 t. 27. [*Cunto*, Adans.; *Jambolana*, Adans.]

Atalantia, Correa in Ann. Mus. Paris vi. (1805) 383. [*Malnaregam*, Adans.]

Simarubaceæ—

Brucea, J. F. Mill., Fasc. (1780) t. 25. [*Lussa*, Rumph.]

Ailanthus, Desf. in Mém. Acad. sc. Paris 1786 (1789) 265 t. 8. [*Pongelion*, Adans]

Euphorbiaceæ—

Codiaeum [Rumph. ex] A. Juss., De Euphorb. gen. tent. (1824) 33. [*Phyllaurea*, Lour.]

Rhamnaceæ—

Colubrina, L. C. Rich. ex Brongniart in Ann. sc. nat. x. (1827) 368 t. 15 f. 3. [*Marcorella*, Neck.; *Tubanthera*, Comm. ex DC.]

Tiliaceæ—

Berrya, Roxb., Hort. bengal. (1814) 42; Pl. Coromandel iii. (1819) 60 t. 264. [*Espera*, Willd.]

Malvaceæ—

Malvastrum, A. Gray in Mem. Amer. Acad., New Ser. iv. (1849) 21. [*Malveopsis*, C. Presl]

Pavonia, Cav., Diss. ii. (1786) App. 2; iii. (1787) 132 t. 45. [*Lass*, Adans.; *Malache*, B. Vogel; *Prestonia*, Scop.]

Sterculiaceæ—

Pterospermum, Schreb., Gen. ii. (1791) 461. [*Velaga*, Adans.]

Cochlospermaceæ—

Cochlospermum, Kunth, Malvac. (1822) 6. [*Maximiliana*, Mart.]

Violaceæ—

Hybanthus, Jacq. Enum. pl Carib. (1760) 2. [*Calceolaria*, Loefl.]

Flacourtiaceæ—

Xylosma, Forst f. Prodr. (1786) 72. [*Myroxylon*, Forst.]

Thymelaeaceæ—

Wikstroemia, Endl., Prodr. fl. norfolk. (1833) 47. [*Capura*, L.]

Pimelea, Banks et Sol. ex Gaertner, Fruct. i. (1788) 186. [*Banksia*, Forst.]

Sonneratiaceæ—

Sonneratia, L. f., Suppl. (1781) 38. [*Blatti*, Adans.; *Pagapate*, Sonner.]

Lecythidaceæ—

Careya, Roxb., Hort. bengal. (1814) 52. [*Cumbia*, Buch.-Ham.]

Barringtonia, Forst, Char. gen. (1776) 75. [*Huttum*, Adans.]

Rhizophoraceæ—

Carallia, Roxb. ex R. Brown in Flinders, Voy. Bot. ii. (1814) App. iii. 549. [*Karekandel*, Adans.; *Diatoma*. Lour.; *Barraldeia*, Thou.]

Myrtaceæ—

Agonis, Lindl., Swan River, App. (1839) 10. [*Billottia*, R. Br.]

Melaleuca, L., Mant. i. (1767) 14 [*Cajuputi*, Adans.]

Verticordia, DC. in Dict. class hist. nat. xi. (1826) 400. [*Diplachne*, R. Br. ex Desfontaines]

Myrsinaceæ—

Ardisia Swartz, Prodr. (1788) 48. [*Kathoutheka*, Adans; ? *Vedela*, Adans.; *Icacorea*, Aubl.; *Bladhia*, Thunb.]

Embelia Burm f., Fl. ind. (1768) 62. [*Ghesaembilla*, Adans.; *Pattara*, Adans.]

Oleaceæ—

Linociera, Swartz in Schreber, Gen. ii. (1791) 784. [*Mayepea*, Aubl.; *Thouinia*, L.; *Freyeria*, Scop.; *Ceranthus*, Schreb.]

Gentianaceæ—

Villarsia, Vent., Choix. (1803) t. 9 pp. [*Renealmia*, Houtt.]

Apocynaceæ—

Carissa, L., Mant. i. (1767) 7. [*Arduina*, *Mill.*; *Carandas*, Adans.]

Alyxia, Banks ex R. Brown, Prodr. (1810) 469. [*Gynopogon*, Forst.]

Ichnocarpus, R. Br. in Mem. Werner Soc. i. (1809) 61. [*Quirivelia*, Poir.]

Convolvulaceæ—

Calystegia, R. Br., Prodr. (1810) 483. [*Volvulus*, Medik.]

Borraginaceæ—

Trichodesma, R. Br., Prodr. (1810) 496. [*Pollichia*, Medik.: *Borraginoides*, Moench.]

Labiatæ—

Plectranthus, L'Hérit, Stirp. nov. (1785 vel 1788 ?) 84 verso. [*Germanea*, Lam.]

Scrophulariaceæ—

Limnophila, R. Br., Prodr. (1810) 442. [*Ambulia*, Lam.; *Diceros*, Lour.; *Hydropityon*, Gaertn.]

Stemodia, L., Syst. ed. 10 (1759) 1118. [*Stemodiacra*, P. Br.]

Artanema, D. Don in Sweet, Brit. Flow. Gard. 2 Ser. iii. (1835) t. 234, [*Bahel*, Adans.]

Lentibulariaceæ—

Polypompholyx, Lehm., Pugill. viii. (1844) 48. [*Cosmiza*, Raf.]

Acanthaceæ—

Dicliptera, Juss. in Ann. Mus. Paris ix. (1807) 267. [*Diapedium*, Koenig.]

Rubiaceæ—

Psychotria, L., Syst. ed. 10 (1759) 929. [*Myrstiphyllum*, P. Br.; *Psychotrophum*, P. Br.]

Campanulaceæ—

Wahlenbergia, Schrad., Catal. hort. goetting. (1814). [*Cervicina*, Del.]

Goodeniaceæ—

Scaevola, L., Mant. ii. (1771) 145. [*Lobelia*, Adans.]

Compositæ—

Vernonia, Schreb., Gen. ii. (1791) 541. [*Behen*, Hill.]

Blumea, DC., in Guillemin, Arch. bot. ii. (1833) 514. [*Placus*. Lour.]

Podolepis, Labill., Nov. Holl. pl. spec. ii. (1806 vel 1807) 56. [*Scalia*, Sims.]

Gynura, Cass. in Dict. sc. nat. xxxiv. (1825) 391. [*Crassocephalum*, Moench.]

NOTES ON SOME NATIVE TRIBES OF AUSTRALIA.

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IN the following pages I shall deal with the sociology, language, and customs of some native tribes located in parts of the continent far removed from each other.

I. SOCIOLOGY OF THE KURNU TRIBE.

In 1902 I contributed a short article to this Society containing an elementary grammar and a Vocabulary of the Kūrnū language.[1] In 1904 I forwarded a supplementary grammar of this language to the Anthropological Society in Paris.[2] In the same year I submitted a description of their initiation ceremonies to the Anthropological Society in Vienna.[3] On the present occasion an account of their sociology will be given. This tribe occupies both sides of the Darling River, from Bourke down to Winbar Station, extending back both northward and southward into the hinterland of the Darling for long distances. Their country also reaches up the Warrego River as far as Ford's Bridge, a small village on that stream. The information contained in the three previous articles above referred to, as well as in the present paper, was gathered by me direct from the natives.

The community is nominally divided into two primary cycles, moieties, groups or phratries, whichever of these names we choose to employ for purposes of distinction.

[1] Journ. Roy. Soc. N.S. Wales, xxxvi., pp. 154 - 179.
[2] Bull. Soc. d' Anthrop. de Paris, Serie v., Tome v., pp. 133 - 139.
[3] Mitteil. d. Anthrop. Gesellsch. in Wien., Bd. xxxiv., pp. 77 - 83.

These cycles are named Mŭkungurra and Kilpungurra, with their feminine equivalents formed by suffixing *ga* to the masculine name. The Mŭkungurra cycle is again divided into two sections called Murruri and Kubburi, and the Kilpungurra cycle is similarly divided into two, called Ibburi and Ngumburi. In each of these four sections the names of the women are modified so as to distinguish them from those of the men. The following table exhibits the masculine and feminine form of each section name, the sections which normally or usually intermarry, and the section name of the offspring.

Table I.

Cycle.	Mother.	Father.	Son.	Daughter.
Kilpungurra	Ngummundyerra	Murruri	Ibburi	Ibbundyerra
	Ibbundyerra	Kubburi	Ngumburi	Ngummundyerra
Mŭkungurra	Murrundyerra	Ngumburi	Kubburi	Kubbundyerra
	Kubbundyerra	Ibburi	Murruri	Murrundyerra

The above table gives the cycle, mother, father, son and daughter on the same line across the page, and requires no further explanation. Everything in the universe, animate and inanimate, belongs to one or other of the two cycles. And every individual in the community claims some animal or plant or other object as his or her totem. The section name is invariably determined through the mother, because the women of a cycle reproduce each other, in continuous alternation. The totems remain constantly in the same cycle as the women and are accordingly transmitted from a mother to her progeny.

In an article contributed to this Society in 1905,[1] I illustrated the sociology of the Barkunjee tribe as comprising only two divisions, Mŭkungurra and Kilpungurra, the men of one division marrying the women of the opposite one. In studying the above table, we observe that there is a bisection of each of the two divisions of the Barkunjee,

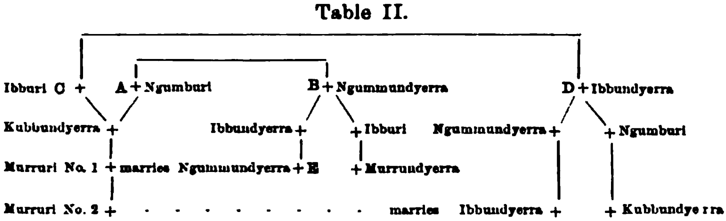
[1] This Journal, xxxix., pp. 118, 119.

so that in the Kūrnū there are four divisions of the community instead of two.

The Kūrnū, like the Barkunjee, possess a further distinctive division into Muggulu and Ngipuru, with their feminine forms Mugguluga and Ngipuruga, meaning sluggish or heavy blood and swift or light blood respectively. Again, like the Barkunjee, the Kūrnū are divided into Nhurrē and Winggu, the Butt and the Branch shade. A man of the Muggulu blood and the Butt shade usually and normally marries a Ngipuruga woman of the Branch shade, subject to variations explained farther on. In regard to the offspring, a Mugguluga mother produces Muggulu children who take their mother's shade. A Ngipuruga mother produces Ngipuru children belonging to her own shade.

The castes of "blood" and "shade" are not necessarily coincident with the other divisions. For example, a Ngipuru man or woman may belong to either cycle or to any section and a Muggulu individual has the same variations. In short, these castes divide the people of every section into two sorts or degrees. The cycles, sections, bloods and shades are used as the foundation upon which the betrothals and marriages are regulated. Before dealing further with this important subject, it will be desirable to introduce another table.

Table II.



In this table, in the lower left hand corner, we have Murruri No. 1; above him is his mother Kubbundyerra; and above her, at A, is her tabular or No. 1 father. A

little way to the right of Ngumburi is his sister Ngummundyerra, marked B, below whom are her children, a daughter and a son. Her daughter Ibbundyerra has a daughter Ngummundyera; and her son Ibburi has a daughter Murrundyerra. Then Murruri No. 1, whom we shall assume to be a Muggulu, marries Ngummundyerra E, as shown in Table 2. She is his normal or No. 1 wife and belongs to the opposite cycle as well as to the Ngipuru blood.

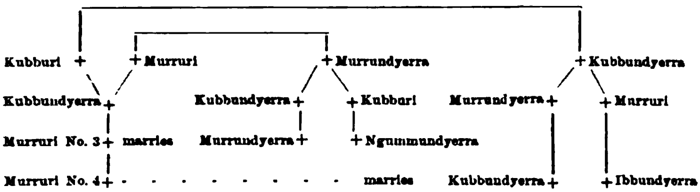
I must digress a moment to explain why Ngummundyerra E is a Ngipuru. Because Murruri No. 1 is a Muggulu his mother must have been a Mugguluga. His mother's father Ngumburi, in the normal course of things, must therefore have been a Ngipuru to enable him to marry a Mugguluga and so produce Kubbundyerra. Ngumburi's sister was consequently a Ngipuruga too, and as descent is counted through the women, his daughter's daughter Ngummundyerra E must also be a Ngipuruga.

But Murruri No. 1 might be allotted Murrundyerra (see Table 2), who belongs to the Muggulu blood like himself. She is the daughter of Ibburi, a Ngipuru man, who must have espoused a Mugguluga and his daughter is accordingly a Mugguluga. In such a case Murruri No. 1 marries a woman of his own cycle and of his own blood division. She may be distinguished as wife No. 2.

Looking again at Table 2 we find Murruri No. 2 in the lower left hand corner, with his mother above him; and higher up at C, her No. 2 father Ibburi. Away in the upper right hand corner is Ibburi's sister Ibbundyerra, marked D, with her children and grand children below her. Then Murruri No. 2 marries Ibbundyerra, of the opposite cycle and opposite blood division who may be styled wife No. 3. Or Murruri No. 2 might have Kubbundyerra assigned him as wife No. 4. She belongs to his own cycle and to his own blood division. I have not considered it necessary to trace out the blood divisions of the No. 3 and No. 4 wives.

The Kubbundyerra of our example in Table 2 had a Ngumburi as her No. 1 father, or an Ibburi as her No. 2 father. She might instead have had a Murruri or a Kubburi as her No. 3 or No. 4 father respectively, as follows:—

Table III.



Kubbundyerra is shown as the same individual for the sake of simplicity, but the woman in Table 2 might be a different Kubbundyerra to the one in Table 3. The Kubbundyerra of our examples represents the section rather than the individual. This Kubbundyerra might have had a husband from any one of four sections. Perhaps her husband was Ibburi as in Table 1, or Kubburi, or Ngumburi, or Murruri, but it makes no difference to her progeny which of the four men she was mated with—her children are Murruri and Murrundyerra just the same. Owing, however, to the above mentioned variations in her possible husbands and her possible fathers, it is evident that there could be four sorts or degrees of Murruris, depending upon their mother's pedigree as well as upon her marriage. These four sorts of men are shown as Murruri Nos. 1, 2, 3 and 4 in the tables. It will be observed, however, that the wife of each of the four men will have nominally the same relationship to him, but through different channels.

The human subject, animals, plants, inanimate objects, the elements, the heavenly bodies—everything on the earth or above it—are divided into Kilpungurra and Mŭkungurra, into Muggulu and Ngipuru, and into Butt and Branch shades. The normal and general practice is for one of these pairs of divisions to intermarry with each other. A

Kilpungurra marries a Mŭkungurra, a Mugulu a Ngipuru, a Butt shade a Branch shade. In explaining Tables 2 and 3 we have seen that these general rules are subject to certain modifications. Sometimes a Kilpungurra mates with a Kilpungurra, a Muggulu with a Muggulu, and a Butt shade with a Butt shade. Another custom of wide prevalence is that a man of a given totem must espouse a woman whose totem is not the same as his. This law, like that of the cycles and other divisions, is subject to departures. For example, a man who is a bandicoot might be allotted a bandicoot wife, although this seldom happens. There is no such thing as a cast-iron partition of the community into two exogamous moieties. The only law of the Kūrnū sociology which admits of no variation, is that the cycles, sections, totems, bloods and shades, are irrevocably transmitted through the mothers.

It is for the elders of the tribes to settle what particular genealogy will be adopted when choosing a husband or wife for any particular person. Previous family marriages and a number of other matters are considered in arranging this point. There are also regulations depending upon the totems of the affianced parties, and upon whether they are the elder or the younger members of the family. The maternal uncles of the parties are in all cases among the principal personages in conducting the betrothals.

It is well known that in most Australian tribes a man's brothers are treated as the nominal or tribal fathers of his children, and that his wife's sisters are treated as nominal mothers. This fact introduces a disturbing element into the genealogies, but it is an advantage rather than otherwise, because it increases the chances of a given man or woman obtaining a spouse. For example, Kubbundyerra's father Ngumburi (Table 2) might not have a

sister, but some of his father's brothers might have daughters, who would be called his (Ngumburi's) sisters, and thus supply the Ngummundyerra marked B in Table 2.

This custom also serves another useful purpose, by means of which we can explain why some old men have very young wives. Let us suppose that the Ngumburi last mentioned was the eldest of his father's family. He (Ngumburi) might easily have a younger brother who was, say, fifteen years his junior. This younger brother, Z, who would in time be the father of a daughter, who would fill the place of Ngummundyerra B in Table 2. Again, Ngumburi might marry early and his tribal sister late, so that by a number of circumstances, all probable enough, Murruri No. 1 might get a wife who was twenty or thirty years younger than himself, although she would be of the strictly proper lineage.

It has been said in an earlier page that the totems, consisting of everything alive and inanimate, are subject to the same divisions and subdivisions as the people themselves. Many of the plants, animals, etc., possess the same relationship to each other as the people, a few examples of which will be given from the Kūrnū. The iguana, carpet-snake and brown-snake are brothers and sisters; the porcupine and bandicoot are similarly related; so are the emu and native companion. The turtle has no relations; neither has the mussel nor the crayfish. The relationships of brother-in-law, maternal uncle and many others are also current. These kinships extend to inanimate nature as well; a spring may be related to a tree; certain stars are brothers and sisters, husbands and wives, and so on.

II. Sharing Game and other Food.[1]

There is a universal custom in every native camp, which regulates the partition of all kinds of game and vegetable

[1] See also my remarks on food regulations in the article contributed to this Society in 1904, Vol. xxxviii., p. 258, seq.

food among the relatives and friends of those who procure the supply. Let us say a hunter has killed a padamellin. Some of his relatives get their share from the fore part of the animal, and others from the hind part. There is a further regulation as to which side of the animal shall be given. Some are alloted their portion from the right side of the padamellin, others from the left side. For example, a certain relation may be given the right hind leg, another the left; the right and left fore legs would be similarly distributed to others. One man would get the loin, another the backbone, another the tail, another the head. The brisket, ribs and internal parts respectively would go to other relatives. The portion which each person would obtain would depend upon his relationship to the hunter. The worst parts would be kept by the hunter for his own use. Emus, opossums, iguanas, fish and other animals are divided on the same principle, with necessary variations according to their shape and size. A somewhat similar distribution is made of yams, grass seeds, berries and other foods.

We have said that a man gets his share of food, according to his relationship to the person who captures it; but this does not restrict him to one special part of every animal, because his relationship to another hunter will entitle him to a different portion of such hunter's game. Say that a man, *A*, is allotted the left hind leg of an opossum by his brother's son. *A* may have a brother-in-law in the camp who will perhaps give him the loin of a kangaroo—the portion of the carcase given by a brother-in-law differing from that given by a brother's son, and so on.

Although a man distributes all the best portions of his own catch of game and eats only a little of the worst parts, yet he shares in the distribution of the game of his relatives and thereby gets some good pieces. Moreover, it looks at

first sight as if a hunter's own wife and children would receive scant attention, but the father and mother of the hunter, and those of his wife if present, see that his family get a proper supply of food. Owing to the native law that a man's father's brothers rank as his fathers, the hunter's children will probably have more than one paternal grand father to look after their food supply.

A white man, unacquainted with the native food regulations, on going through a camp at feeding time and seeing them dividing the day's takings, would conclude that the animals were merely cut up and divided among all the people. What actually takes place is, that each hunter gives away all the choice pieces of his own catch and receives donations from his relatives. In the end the result is substantially the same as if the game were divided equally in the first instance, but with the advantage that every person is taught to divide with his own kindred.

An old or feeble person, although not a relation, would be given something out of the day's catch; and if any of the party had been unsuccessful in the chase or in obtaining other food, some of the people would see that he did not go hungry. I have often heard stockmen and other uneducated white people say how greedy a blackfellow is, and how he will sit and eat up food without giving his wife any. He is acting in accordance with custom, because he knows that it is the duty of certain persons among the woman's friends to give her a portion. The yarns we sometimes read in books and newspapers regarding the holding capacity of a blackfellow's stomach are equally baseless.

In 1882 Mr. Edward Palmer, when describing the customs of certain Queensland tribes, said:—"Division of game takes place according to old established rules, in which the natives practice considerable self denial, the

hunter often going short himself that others might have their recognised share. When a kangaroo is killed, the hind leg is given to the hunter's father, with the back bone; the other hind leg to his father's brother; the tail to his sister: the shoulder to his brother; the liver he eats himself. Sometimes his own wife will be left without any, but in that case it seems to be the rule that her brother gives her of his hunting, or someone else on her side. She will not get much from her blackfellow, unless there is a surplus. All game has to be shared according to rule, the best part going to the father's camp, the next to the father's brothers. A blackfellow would rather go short himself and pretend he was not hungry, than incur the odium of being greedy in camp, or neglecting the rights of hospitality. Snakes were broken in pieces and handed round."[1]

At my request, a valuable correspondent in the Alice Springs district, Central Australia, sends me the following rules regarding the partition of game there. If a man kills, say a kangaroo, he takes it to the camp and divides it amongst his relations. He gives the tail to his father's brother's son; the loin and fat to his father-in-law, if present; the right hind leg to his brother; the left hind leg to his father; the ribs to his mother-in-law, if present; the forelegs to his father's younger sisters; the head to his wife. The hunter himself takes only the inner parts and the blood. He then waits till he receives a share from some of the other hunters who are related to him.

Mr. James Dawson, in dealing with the aborigines of the south-western district of Victoria, in 1881, reported as follows:—"There are strict rules regulating the distribution of food. When a hunter brings game to the camp, he gives up all claim to it, and must stand aside and allow the best portions to be given away, and content himself

[1] Journ. Anthrop. Inst., XIII., 285.

with the worst. If he has a brother present, the brother is treated in the same way, and helps the killer of the game to eat the poor pieces, which are thrown to him, such as the forequarters and ribs of the kangaroos, opossums and small quadrupeds, and the back bones of birds. The aboriginal narrator of this custom, mentioned that when he was very young he used to grumble because his father gave away all the best pieces of birds and quadrupeds, and the finest eels, but he was told that it was a rule and must be observed. The women also divide the food they collect, which is mainly vegetable. This custom is called 'yūrka bāwhār,' meaning 'exchange.' . . The grey bandicoot belongs to the women and is killed and eaten by them, but not by the men or children."[1]

Mr. J. P. Gell, reports that among the tribes about Adelaide, in South Australia, grubs living in the bark of trees were eaten by the men only.[2]

III. Sociology of the Chau-an Tribe.

The Chau-an tribe have their hunting grounds on the Katherine River and surrounding country. On the south they are bounded by the Yungmunni community, about Elsey Creek, whose sociology was described by me for the first time in this Journal in 1900.[3] With the help of a capable and reliable resident of that district, I have since then been studying the sociology of the Chau-an people, and am pleased to be able to supply the following infor-

[1] Australian Aborigines of Western District of Victoria, (Melbourne, 1881) pp. 22 and 52.

[2] Tasmanian Journal of Natural Science, (1842), I., p. 112.

[3] This Journal, xxxiv., 130. The equivalence of the section names of the Chau-an, to those of the Yungmunni tribe about Elsey Creek, is as follows:—Plienban is equal to Eemitch, Aratchban to Uwannee, Kamaranban to Unmarra, and Wamood to Tabachin. In the lower half of the table, Kangala corresponds to Yungalla, and the remaining sections correspond in the order in which they are printed.

mation, which has never before been published. Like their Southern neighbours, their women can be classified into two cycles of four sections each, making eight divisions in all. Up to the present, I have not been able to discover feminine forms of the section names.

I am informed that all the tribes from Katherine River to Port Darwin, have the same sociology as the Chau-an. The names of the eight sections are different from those at the Katherine, but the principle is just the same.

Table IV.

Cycle.	Mother.	Father.	Children.
A	Kangala	Plienban	Paralee
	Watchban	Aratchban	Pongaree
	Paralee	Kamaranban	Watchban
	Pongaree	Wamood	Kangala
B	Plienban	Kangala	Wamood
	Aratchban	Watchban	Kamaranban
	Wamood	Pongaree	Aratchban
	Kamaranban	Paralee	Plienban

In studying the upper half of the above table, or cycle A, we see that the women in the "mother" and "children" columns reproduce each other in an established order, and this series is continaully repeated. Kangala has a Paralee daughter, who has a Watchban daughter, who has a Pongaree daughter, whose daughter reverts to the original Kangala section. A similar invariable order of succession exists among the women of Cycle B. As regards the marriages of the sections, a man of the Plienban section can marry a Kangala, as his direct or tabular wife, which can be called wife No. 1, or he can espouse Watchban as No. 2, or Aratchban as No. 3, or Plienban as a No. 4 wife. And as regards the progeny, if Plienban marries Kangala his children will be Paralee, who may be called his No. 1 family. If he takes a Watchban as his wife, his children

will be Pongaree, which we shall distinguish as his No. 2 family. If he weds an Aratchban his children will be Kamaranban, who can be denominated his No. 3 family. And if Plienban should espouse a Plienban woman his children would be Wamood, whom we shall set down as his No. 4 family. From this we can readily see that the children of a given man, may have any one of four section names, this matter depending altogether upon the woman who is his wife; and consequently there cannot be any recurrent succession of the section names through the men.

Two of Plienban's possible wives and two of his possible families belong to Cycle A, and two to Cycle B. A No. 1 wife, and consequently a No. 1 family, which are those given in Table IV. on the same line across the page, are the most general, and may be considered the normal relationships. A No. 2 wife and family are the next most usual, No. 3 and No. 4 wives and resultant families are not so common, although quite legal in native society.

We have just seen that a man may have a wife or family belonging to any one of four sections. Although a woman may likewise have a husband from any one of four sections, this fact makes no difference at all to her progeny. For example, a Kangala woman might be married to Plienban, or Aratchban, or Watchban, or Kangala, but her children would be Paralee all the same, because the succession of the sections through the woman is absolutely invariable. But owing to the four possible husbands obtainable by women of the Kangala section, it is evident that there could be four sorts of Paralees, according to whom their fathers were.

In the Ohau-an, as well as in all the other tribes reported by me, in the Northern Territory, succession of the totems does not depend upon either the father or the mother, but

is regulated by locality, and I shall now endeavour to describe how this is carried out. The folk-lore of these people is full of fabulous tales respecting the progenitors of every totem. Some of them were like the men and women of our own time, whilst others were mythologic creatures of aboriginal fairyland. In those olden days, as at present, the totemic ancestors consisted of families or groups of families, who had their recognised hunting-grounds in some part of the tribal territory. They were born in a specific locality, and occupied it by virtue of their birthright. Some of them would be, let us say, cockatoos, others dogs, others kangaroos, others snakes, and so forth. The members of these family groups were sub-divided into the same eight sections which we find among the people now.

When one of these legendary individuals died, his spirit was supposed to settle itself in some well known spot in his own hunting grounds, such as a rock, or tree, or hill, or soakage, or perhaps it went into the ground. The individual might, during his lifetime, have identified himself with different places, such as where he camped at various times, or did a notable deed, or worked some ceremonial incantation or the like. The sites of these several actions were scattered over different parts of the locality he occupied, as well as over the hunting grounds of neighbouring friendly tribes, whom he was in the habit of visiting. All the members of his own family group had, as a matter of course, equal rights to the same hunting grounds as he, and located their spirits at certain places in a similar manner.

In the course of many generations, all the camping places, water-holes, large rocks, springs, hills, trees and remarkable objects in their own tract of country would become saturated, so to speak, with spirits of all sorts. There

would be bandicoots at one place; frogs would infest others; some would be reeking with porcupines; whilst other spots would be haunted by snakes. Certain of these fabled areas were large, and others were of small extent. Some of the traditionary totems were invested with greater authority than others, like the head men of totemic groups at the present time. Some animals of a kind were numerous, as now, and left a prolific family of spirits, whilst others were few, and left behind a limited number of representatives. The exact location of every one of these notable retreats has been handed down by oral tradition to all the present natives, who give a poetical and much embellished account of the doings of their various ancestors, freely mixed with superstition.

The people of the far past time used to assemble, as at present, for ceremonial purposes, such as initiating the young men, making rain, etc., and consequently every man and woman had travelled over most of the tribal territory. After the death of a given individual, his spirit would revisit all the places which had figured prominently in the man's life, sometimes sojourning at one of these spots, sometimes at another, but the "headquarters" of the spirit would be at a particular soakage, rock, etc., in the old hunting grounds.

Whether in human shape or as monstrosities, these creatures of aboriginal fancy or exaggeration were possessed of supernatural powers. Some of them could form springs and watercourses; some could raise up hills and rocks at certain historic spots, whilst others could cause trees or patches of scrub to grow in remarkable forms. Moreover, these fabled retreats are related to one another, in the same way that human beings are related. For example, a soakage may be the mother's brother of a certain hill; a rock may be the father of a particular

sand-hill; a tree may be the brother of a rock-hole, and so on.

In all aboriginal tribes there is a deeply seated belief in the reincarnation of their ancestors. The original stock of spirits, so to speak, perpetually undergo reincarnation from one human being to another. The natives are quite ignorant of the natural facts of procreation, and believe that conception is altogether independent of sexual intercourse. When a woman for the first time feels the movement of the child in the womb, commonly called quickening, she takes particular notice of the spot where it occurred and reports it to the people present. It is believed that the spirit or soul of some deceased progenitor has just at that moment entered the woman's body. The entry may have been by the way of some one of the natural openings, or through any part of the skin, the mode and place of ingress being immaterial to these ethereal beings. When the child is born, it will have assigned to it the totemic name of the mythic ancestor belonging to the particular locality. For example, if the quickening happened near a remarkable rock, or hill, or waterhole, or camping place, which was known to be haunted by the traditionary spirit of a galah, the infant would belong to the galah totem, altogether independently of either the father or the mother.

Regarding the succession of the totems, it is important to remember that in all our aboriginal tribes, a wife is taken away into the family group or triblet of her husband, and roams about with him through his country. If he be, for example, a crow, he and his wife will spend most of their time amongst the specific haunts of his ancestors. When his wife for the first time becomes conscious of being enceinte, she will probably be staying at a spot associated with some of the crows of earlier times, because

she is living in a crow man's country. In such a case the child, when born, will be denominated a crow the same as its father. Should the woman, however, at the time of the quickening, happen to be on a visit to her own people in the district where she was born and brought up, the chances are in favour of the interesting fact being connected with one of her own ancestors, say a porcupine; then the child will get the totemic name of the porcupine, the same as its mother. Again, if the woman, at the critical moment, happened to be at a part of the common hunting grounds, where the pigeon spirits are supposed to predominate, her infant would be a pigeon. In this way there could be children of the same parents all possessing different totemic names, many examples of which are found among the Chau-an, Chingalee and other tribes. But as the married pair of our example would naturally frequent their own crow tract more than anywhere else, as stated in the last paragraph, their crow progeny would probably be the most numerous, or it might be that all their children would be crows. This has given rise to the erroneous statements made by other investigators that the descent of the totems is through the father.

In some of these historic places the spirits of several different kinds of animals which were closely related to each other, are now said to inhabit the same rock, tree, spring, etc., or at any rate to occupy places in close proximity to each other, and roam about in company the same as they did when "in the flesh." If a mother first felt the movements of the fœtus at that locality, it would be almost impossible to say which of the spirits had entered her body, and consequently in such cases it is always difficult for the old men to decide the denomination of the totem to which the child shall be deemed to belong.

Rev. L. Schultze, in speaking of the tribes on the Upper Finke River, states:—"These natives believe that the

souls of the infants dwell in the foliage of the trees, and that they are carried there by the good mountain spirits 'tuanyiraka,' and their wives, 'melbata.' The nearest tree to a woman when she feels the first pain of parturition, she calls 'ngirra,' as they are under the impression that the 'guruna,' or soul, has then entered from it into the child. Such a tree is left untouched, as they believe that whoever should happen to break off even a single branch would become sick. But if the tree should be injured or broken down by winds or floods, that person would get ill whose 'ngirra,' the tree was.'"[1]

When Rev. C. G. Teichelmann, and Rev. C. W. Schürmann were engaged in missionary work among the aboriginal tribes in and around Adelaide, the capital of South Australia, in 1840, the blacks called them 'Pindi-meyu,' or "men of the den," because in their white complexions and unusual activity, they believed that they recognised their forefathers returned from the habitation of the dead. 'Pindi,' a large den or pit, was the place of souls, and was situated in the far west, whence the souls of the unborn came, and, hovering among the grass-trees, waited for the hour of conception. When the infant into whom the spirit entered, had finished its course on earth, and was buried, the spirit, 'towilla,' returned to 'Pindi."[2]

Rev. Geo. Taplin, speaking of the tribes about Mount Freeling, 300 miles northerly from Adelaide, describes how these spirits manage to secure a mother. A tiny spirit meets a woman in the bush and throws its little club at her foot, the end of the weapon making a little puncture under the great-toe nail, through which the spirit enters, and in due time is re-born. The entry may be under the thumb nail, and is accomplished in a similar manner, with the

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[1] Trans., Roy. Soc., S. Australia, (Adelaide, 1891), xiv., 239.

[2] Tasmanian Journal of Natural Science, (1842), I., pp. 111 and 120.

same result. The sex of the infant is determined by that of the spirit who enters the woman's body.[1] Mr. Schürmann, in 1846, reported the same belief among the tribes about Port Lincoln, more than 350 miles by land, via Port Augusta, from Adelaide.[2]

On the Daly River, in the Northern Territory, Rev. Donald McKillop reports that souls are shut up in hills. Daly River is twenty-one degrees of latitude distant from Adelaide, which shows the wide geographic range of the native belief in reincarnation. He says:—"A few miles from where we live, and not far from the river (Daly), there is a hill, called in the native language 'Alalk-yinga,' that is "the place of children." The natives believe that the souls of future children—or perhaps the children, bodies and souls—are shut up there. They are under the care of one old man. He has to see that they do not escape, and to supply them with water. This he does by means of an underground communication with the river about a mile away. The range, of which the hill in question is the last one, runs right to the river. When a child is to be born, this old man sees to the business."

Mr. G. W. Earl, when among the natives of Coburg Peninsula, in the extreme north of Australia, in 1846, stated that "the spirits of the dead are recognised in the strangers who visit their country."[4] Coburg Peninsula, where Mr. Earl observed the belief in reincarnation, and Port Lincoln, where Mr. Schürmann, in the same year, reported a similar belief, are separated by 24 degrees of latitude, or about 1,500 miles.

When residing at Perth, Western Australia, in 1842, Mr. G. F. Moore reported that the word 'djandga' signified

[1] Folklore, Manners, etc., S. A. Aborigines, (1879), p. 88.
[2] Reprinted in Native Tribes of South Australia, (1879), p. 235.
[3] Trans. Roy. Soc. S. A., (Adelaide, 1894), XVII., 262.
[4] Journ. Roy. Geog. Soc., (London, 1846), XVI., 241.

"the reappearance of deceased persons. It is also applied to Europeans, who are supposed to be aborigines, under another colour, restored to the land of their nativity."[1] From Adelaide, where the same belief was recorded, to Perth, is about 1,300 miles in a direct line on a map of Australia.

Mr. E. S. Parker, a protector of the aborigines of Victoria, wrote in 1854:—"The aborigines had a distinct belief of the existence of their souls after death. . . . There were also well defined traces of a belief in transmigration of souls. . . . It is well known that, on the first appearance of the colonists, the opinion was taken up, and long maintained among them, that they were their deceased progenitors returning to their former haunts."[2]

The few examples I have quoted, show that the aboriginal belief in the reincarnation of souls, has been known and reported upon by white men, from 1840 to the present time. The localities I have chosen for these examples are situated in the extreme north, the west, and the south of the Australian Continent.

IV. Languages of Tribes about Alice Springs.

During recent years, some friends of mine have had business at the mining fields, in the Alice Springs district, Northern Territory. The journey from Adelaide to Alice Springs, although a somewhat long one, is quite easily accomplished. A train leaves Adelaide for Oodnadatta, 737 miles distant, on every alternate Monday throughout the year, arriving at Oodnadatta on Wednesday at 7 p.m.; fares, first class £5 10s. and second class £3 17s. 6d. On Thursday morning, at 8 a.m., a coach carrying mails and passengers, starts from Oodnadatta for Alice Springs, the

[1] Descriptive Vocabulary of the Language of the Aborigines of Western Australia, (London, 1842), p. 28.

[2] The Aborigines of Australia, (Melbourne, 1854), p. 25.

through fare being £7, and the time occupied on the road ten days. Passengers by the coach find their own rations, a fresh supply of which can be had at the following stations *en route*, viz.:—Hamilton Bore, Blood's Creek, Horse-shoe Bend, and Alice Well. Passengers are allowed 25 pounds weight of luggage, independently of their rations; all over that weight is charged at the rate of six pence per pound. Leaving Oodnadatta in the coach, Alberga Creek is reached in 40 miles; 30 miles further brings us to Hamilton Bore; 36 miles more is Blood's Creek and in another 30 miles we reach Charlotte Waters, 136 miles from Oodnadatta. From Charlotte Waters to Goyder's Creek is 29 miles; Old Crown Point is 25 more; another 27 brings us to Horse-shoe Bend. From there to Depot Well is 13 miles, and in 14 more we reach Alice Well, 108 miles from Charlotte Waters. From Alice Well to Frances Well is 22 miles; Deep Well is 27 more; Ooraminna is another 24 miles, and in 30 miles more we arrive at Alice Springs, 347 miles from Oodnadatta.

I have given this short account of the journey to Alice Springs, in the hope of encouraging scientific men residing in any part of Australia, to go out among the aborigines, for the purpose of supplementing our knowledge of their dialects, beliefs, and customs generally. The expense of the trip would be comparatively trifling. The two black-fellows, "Jimmy" and "Warwick," who acted as interpreters to Messrs. Spencer and Gillen, are natives of the Lower Finke and Lindsay Rivers country, where they are usually employed on stations and otherwise. They can be heard of any time at Charlotte Waters. The tribe in which these men were born and brought up contains four sections in its social structure, namely, Panungka, Koomara, Parulla, and Bultara.

A township called Stuart was laid out some 20 years ago about a mile and three-quarters south of Alice Springs

telegraph station. The town is situated on the right bank of the Todd River, somewhat less than half a mile below the junction of Charles Creek, and is only a primitive country village.

The journey from Stuart or Alice Springs to Port Darwin is sometimes undertaken by bicyclists. Mr. McDonald was the most successful, as he did the journey without any outside help. He was, however, fortunate in having a good rain on most of the sandy part of the way. Rain on a sandy camel-pad makes it almost as good as asphalt for a bicycle. Mr. A. Lennox was another of the successful wheelmen from Alice Springs to Port Darwin. Several others have done the journey, but have taken longer time, and have had assistance in various ways from other travellers. Footmen also make the trip right through. Occasionally, by their own carelessness, they get into distress and cut the telegraph wire, a recognised practice in extreme cases. The line maintainers then go out and succour them, as well as repair the damage to the telegraph line. The distance from Alice Springs to Port Darwin is about 1,030 miles; the last 200 miles, from Pine Creek to Palmerston, being covered by a railway.

To the east and north-east of Alice Springs, a good many blackfellows are employed by the miners at Winnecke and Arltunga, as water drawers, wood collectors and horse shepherds. The native women do washing and general laundry and scullery work. The younger and better looking ones are often promoted to the position of temporary wives of their employers. The ubiquitous rabbit is very numerous in that region, and is a valuable addition to the aboriginal food supply. In 1899, I described the eight intermarrying sections in this region,[1] and at present the

[1] Proc. Amer. Philos. Soc., XXXVIII., 76. The Kat'-tit-ya or Kat'-titch-a tribe about Barrow Creek, have a similar organization to that of the Arran'da, with some modifications in the section names. The Kattitya tribe has been erroneously reported as the "Kaitish" by some writers.

grammatical structure of their language will be briefly touched upon.

All the way from about Oodnadatta or Alberga Creek to Alice Springs and Glen Helen Cattle Station, the people speak the Arran'da language, or dialects of it. In 1890, Rev. H. Kempe prepared a grammar and vocabulary of the "Language spoken in the Macdonnell Ranges.[1] He did not however, observe that there are two distinct pronouns in the first person of the dual, and also of the plural. In one of these pronouns, the individual addressed is included with the speaker, and in the other the individual addressed is excluded. I therefore propose to supply a new table which has been forwarded at my request by a resident of that part of the country.

Singular	1st Person	I,	Ta or yinga
	2nd ,,	Thou,	Unta or nga
	3rd ,,	He,	Era

'Ta' and 'unta' are used with transitive verbs; 'yinga' and 'nga' are used with intransitive verbs.

Dual	1st Person	We, incl.,	Ngilina
		We, excl.,	Ilina
	2nd ,,	You,	Mbala
	3rd ,,	They,	Eratara
Plural	1st Person	We, incl.,	Nganuna
		We, excl.,	Anuna
	2nd ,,	You,	Rankara
	3rd ,,	They	Etna

In regard to the "double we" in the dual, there are some variations, depending upon the relationship existing between the speaker and the party spoken to. For example if a father speaks to his son, he says ngilaki instead of ngilina, as, Ngilaka araka larityika, we (dual), kangaroo for must go. Emphatic forms are, ngilanta, we, (dual), only. Ngunanta or ngunantara, we, (plural), only.

[1] Trans. Roy. Soc., S. Australia, xiv., 1-54.

The Lō-rit-ya or Lō-ritch-a tribe adjoins the Ar-ran'-da on the west. Their country is approximately from the Musgrave Ranges, northerly via Lake Amadeus, to the Ehrenberg Ranges. In 1900, I reported that the Lō-rit-ya were divided into four intermarrying sections, called Panungka, Koomara, Parulla and Bultara. I stated that the same organisation, with some slight modifications in the names of the four sections, as well as in the order of their intermarriage, extended westerly from Lake Amadeus across the State of Western Australia to the Indian Ocean. I also reported that the children took their descent through the mother.[1]

The Lō'-rit-ya, in common with the Ar-ran'-da and other neighbouring tribes, practice the rites of circumcision and subincision. Certain mutilations are also performed upon the young women, the result of which being that the vaginal orifice is permanently enlarged. Full particulars of all these rites, and of the impressive ceremonies connected with them, were communicated by me to the American Philosophical Society at Philadelphia in 1900.[2]

The grammatical structure of the Lō-rit-ya language is the same as that of the Ar-ran'-da. The nouns, pronouns, verbs and other parts of speech, are declined in a similar manner, and several words of their vocabulary are substantially the same. I shall therefore content myself with giving a list of the pronouns, and a short vocabulary, both of which have been obtained direct from the natives by a throroughly capable correspondent residing in that district. Below is a table of the personal pronouns in the nominative case. The first person of the dual, as well as the first person of the plural, contains two distinct forms, one of which includes with the speaker the individual who is

[1] Proc. Amer. Philos. Soc., Philadelphia, xxxix., 89, with map.

[2] Op. cit., pp. 622-638.

addressed, and the other excludes him. The first of these is marked "inclusive," and the latter "exclusive" in the following tabulation:—

Singular	1st Person	I,	Ngaiulu
	2nd ,,	Thou,	Nuntu
	3rd ,,	He,	Paluru
Dual	1st Person	We, incl.,	Nuntungali
		We, excl.,	Ngali
	2nd ,,	You,	Numbali
	3rd ,,	They	Palurukutara
Plural	1st Person	We, incl.,	Nguntunganana
		We, excl.,	Nganana
	2nd ,,	You,	Ngurangari
	3rd ,,	They	Tana

The possessive pronouns are as under:—

Singular	1st Person	Mine,	Ngaiuku
	2nd ,,	Thine,	Nuntuba
	3rd ,,	His,	Palumba
Dual	1st Person	Ours, incl.,	Nuntungalimba
		Ours, excl.,	Ngalimba
	2nd ,,	Yours,	Numbalimba
	3rd ,,	Theirs,	Palumbakutara
Plural	1st Person	Ours, incl.,	Nuntunganamba
		Ours, excl.,	Nganamba
	2nd ,,	Yours,	Ngurangarimba
	3rd ,,	Theirs,	Tanamba

Substantially the same dialect extends south-westerly from the Lō-rit-ya country to the Blythe and Petermann Ranges, and goes a long way into Western Australia. Among the Lō-rit-ya people the septum of the nose is pierced in both sexes, and they have the same belief concerning re-birth, which I have reported in earlier pages as existing among the Chau-an tribe. The same belief reaches far into Western Australia.

Loritya Vocabulary.

The following list of eighty-nine of the most commonly used words in the Lō-rit-ya language has been written down

from the mouths of the native speakers, by one of my most valued correspondents in that locality.

Family Terms.

Man,	pata	Woman,	kunka
Mankind,	mutu	Mother,	yako
Father,	katu	Elder Sister,	kangura
Elder Brother,	kuta	Younger Sister,	malangu
Younger Brother,	malungu	Infant, neuter,	pipiri

Parts of the Human Body.

Head,	kata	Foot,	tyina
Eyes,	kuru	Knee,	mardi
Nose,	mula	Blood,	ngurka
Tongue,	talinya	Penis,	kalu
Teeth,	kadidi	Vagina,	tyuka
Ears,	pina	Anus,	kunnatan
Hand,	mara	Excrement,	kunna
Elbow,	nguku		

Inanimate Nature.

Sun,	tyintu	Rock,	walu
Moon,	pira	A Stone,	buli
Fire,	waru	Sand,	karu
Water,	kape	The Ground,	manta
Camp,	ngura	Pipe-clay	ukuna
Smoke,	buyu	Red Ochre	ulba mapanu

Animals.

Opossum,	waiyuta	Wild Dog.	papa inura
Porcupine,	untia	Emu,	kalaia
Rock Wallaby,	wari	Eaglehawk,	kaluwara
Red Kangaroo,	malu	Pelican,	kabilyalku
Grey Kangaroo,	kanala	Crow,	kanka
Bat,	ulbulbine	Iguana,	wongapa
Tame Dog,	papa	Louse,	kulu

Trees and Plants.

Grass tree,	ulunkuru	Beefwood,	iltyantyi
Red-gum tree,	itara	Bullrushes,	unka

Implements, etc.

Stone Tomahawk,	ilipa	Womera,	meru
Stone Knife,	tula	Boomerang	ulbarinya
,, ,,	irkili	Wooden Trough	kuntila
,, ,,	tangu	Yamstick,	wonna
Shield,	kutityi	Upper Millstone,	miri
Spear,	katyi	Lower ,,	tyu-a

Adjectives.

Large,	buntu	Good,	pala
Small,	wima	Bad,	kuya
Straight,	tukaruru	Hungry,	a-in-ma
Crooked,	kalikali	Stinking,	boka

Verbs.

Stand,	ngarange	Talk,	wonkanye
Sit,	ninanye	Beat,	bunganye
Walk,	yananye	Throw,	runkanye
Eat,	ngalkunye	Carry,	katinye
See,	nanganye	Bite,	patanye
Give,	yunganye		

Numerals.

One,	kutu	Several,	mankura
Two,	kutara		

V. Native Shoes in the Northern Territory.

To protect their feet from the sharp stones in rugged country, when travelling any considerable distance, or from the hot sand of the desert, the natives of the Northern Territory sometimes make shoes or sandals from the bark of the tea-tree, with a string tied over the foot to keep them on. This string is made from the bark of a shrub with a yellow flower, which grows on the sandhills. In some districts the shoe itself is made with strands of the bark of the same tree, worked in the manner of netting, and is fastened on the foot as just stated. In other parts these shoes are made of animal fur, woven into a net with very small meshes. Shoes are also sometimes made of emu

feathers matted together to form the soles, and are fastened on the foot with string in the usual way. It has been erroneously said that such shoes, which are worn only by old conjurors, do not leave any tracks on the ground which could be detected by others, but the real explanation of their immunity from pursuit is because no man would attempt to follow the tracks of an individual using shoes of this character, from a superstitious dread of the magical powers of the wearer. Such shoes are very seldom worn, but are occasionally used by the Shamans of the tribe when engaged upon some special work, such as the making of rain, driving away evil spirits, or such like.

Mr. E. M. Curr thus refers to such shoes in his valuable work:—"It was discovered in 1882, or thereabouts, that the blacks to the westward of Lake Eyre, on the Musgrave Ranges, and it is believed in some other portions of Central Australia, wear a sort of shoe when they attack their enemies by stealth at night. Some of the tribes call these shoes 'kooditcha,'[1] their name for an invisible spirit. I have seen a pair of them. Their soles were made of the feathers of the emu, stuck together with a little human blood, which the maker is said to take from his arm. They were about an inch and a half thick, soft, and of even breadth. The uppers were nets made of human hair. The object of these shoes is to prevent those who wear them from being tracked and pursued after a night attack. It is only on the softest ground that they leave any mark, and even then it is impossible to distinguish the heel from the toe. The blacks say they can track anything that walks, except a man shod with 'kooditcha.'"[2]

VI. Bullroarers.

In 1840, when the Lutheran Missionaries, Teichelmann and Schürmann, already mentioned in this article, were

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[1] The i is sounded as in "mite."

[2] The Australian Race, (Melbourne, 1886), I., 148.

labouring among the tribes in the Adelaide district, they discovered and described two kinds of bullroarers, a smaller and a larger, used by the aborigines in their secret ceremonies. The 'kadnomarngutta' they speak of as being "a thin, oval piece of wood, about five inches long, and an inch and a half wide, tied to a string by which the natives swing it rapidly round, and thus cause a humming noise. Females and children are not allowed to see it, much less to use it." The 'wimmarri' was the same in shape as the 'kadnomarngutta' but larger. It was invoked in the incantations of the natives whilst out hunting.[1] The name of the instrument was also repeated while the bodies of the youths were being scarred, believing that it would soothe the pain.

VII. Naming of some Native Languages.

A custom of wide geographic distribution, is that of naming a language after its negative adverb. In 1846, Mr. G. Windsor Earl in his paper "On the Aboriginal Tribes of the Northern Coast of Australia," reports as follows:—"The Coburg Peninsula is occupied by four distinct tribes. They are distinguished among each other by the term which in the particular dialect of each designates the monosyllable 'No.' About Croker Island and Raffles' Bay the tribe is termed 'Yaako.' The Port Essington tribe goes by the name of 'Yarlo'; the western tribe by that of 'Iyi'; and the great southern tribe by that of 'Oitbi.'"[2]

In 1866, Rev. Wm. Ridley[3] in his book on the Kamilaroi tribe of New South Wales, also records the nomenclature of the language from the negative adverb. 'Kamil' means 'No.' This method of distinguishing a language, extends

[1] Grammar of the Language of the Natives of Adelaide, 1840, pp. 7, 55, and 73.

[2] Journal of the Royal Geographical Society, (London, 1846), vol. xvi., pp. 241 - 242.

[3] Kamilaroi', Dippil, etc., (Sydney, 1866), p. 14.

from the Kamilaroi southerly, to Port Phillip in Victoria, and northerly to the Mary River in Queensland. To Mr. Earl and Mr. Ridley belong the honour of first discovering this peculiarity in the naming of some of the Australian languages. It is worthy of note that from the most northerly of the tribes reported by Mr. Earl, to the southern limits of the tribes practising Mr. Ridley's discovery, the distance is about 2,000 miles, which may be another link in the evidence of the common ancestry of Australian tribes. Between the two extreme points mentioned, there are extensive regions occupied by tribes whose dialects are not named in the manner referred to.

In 1903 I reported some other methods adopted by certain tribes of New South Wales and Victoria, in naming their dialects, to which the reader is referred.[3]

VIII. Gure or Avenging Party.

Among the aboriginal tribes inhabiting that portion of the State of Victoria, watered by the Upper Murray, Mitta Mitta, Ovens, Upper Goulburn and Yarra Rivers, if one of their men had been slain by some person in a neighbouring tribe, the method of avenging the injury was known as 'gurē.' It was believed that if a man's death were not avenged, his spirit would saunter about and harass his relations. In consequence of this superstitious belief, the punishment of the offender was carried out at the earliest auspicious juncture.

The following is an abbreviated account of the procedure of a gurē expedition, as narrated to me orally by an aboriginal native of the Mitta Mitta River, in north-eastern Victoria.

The brothers and friends of the murdered individual, accompanied by the elders or leading men, muster at the 'ngulubul,' or private meeting place of the men, and discuss

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[3] This Journal, xxxvii., pp. 244 and 250.

the best course to be pursued in dealing out retribution to the guilty party. Some of the hair, or it may be portions of the skin, which had previously been secured from the body of the murdered man, are produced at this meeting, for the purpose of infusing into the minds of those present a desire for speedy retaliation.

The population of a certain locality often consisted of a number of families, who were so far independent, that they might in the aggregate be called sub-tribes. It not infrequently happened that feuds arose between these family groups, and murders occasionally took place. When a wrong of this kind was inflicted upon a weak sub-tribe, which was not able to retaliate, a messenger was sent to report the facts of the case to the other family groups with whom they were connected by ties of kinship, asking for their assistance. The messenger carried with him a flat stick about eighteen inches or two feet in length, and about an inch and a half wide. This stick was marked or ornamented with lines and nondescript devices by means of a marsupial's tooth, and was painted with red ochre. Instead of a wooden message stick, the bone of an emu's leg, or that of a kangaroo's leg, was sometimes used, being marked with a flint in the same manner as the piece of wood.

The neighbouring people who were summoned in this way usually responded, because they might require similar help some day for themselves. On reaching the common meeting ground indicated by the messenger, a party of warriors was selected to proceed into the country of the wrong-doer. Then there was great greasing and straightening and sharpening of spears. Boomerangs, clubs, shields and other weapons were duly examined, and all necessary preparations made for the projected foray. Some of the cleverest sorcerers available were there with their para-

phernalia of enchantment, and instruments of deadly potency. Every man pulled his beard up into his mouth and bit it with savage grimaces. When all the preliminaries had been settled, the chosen band, greased and painted for the occasion, started forth on their mission. The minor details of the expedition are so similar to those of the 'Pirrimbir,' which I have described elsewhere[1] that the most important portions only need be here touched upon.

The party travelled on till evening and camped for the night, screening their fires so that they could not be seen at a distance. Early next morning a tree was marked with zig-zag or irregular lines and ovals of the usual native pattern, the marks extending from near the ground, up along the bole as high as the men could reach by sitting on each others' shoulders. The marks were chopped into the bark with sharpened sticks or chipped stones, or with tomahawks. A gum tree, or a grey-box tree was preferred, if available, on account of the smooth bark. Every man of the contingent took part in marking the tree, in order to transfer as much magical influence to it as possible, until it was, so to speak, surfeited with mischief. Another reason for all the men participating in the marking of the tree is to strengthen the bond of union amongst them, so that none of them can feel any remorse, or give such timely warning to the doomed man as would enable him to escape. While the work is in progress, some of the principal magicians rub the marks with bullroarers, quartz-crystals and human fat to augment the effectiveness of the proceedings, and cause dismay in the heart of the enemy.

When the marking of the tree has been completed, the men dance or jump around it, singing 'Wure bunnungandha dumballadha,' several times in succession. The object

[1] This Journal, vol. xxxviii., pp. 239 – 252. See also photograph of the marked tree.

of the entire ceremony is to charm the intended victim so that he will not go away from the camp he may then happen to be in, but will remain there spell bound and powerless, till his pursuers reach him. At each of their camping places on the journey forward, exactly the same procedure is gone through, including the marking of a fresh tree every morning. Having reached their destination and discovered the whereabouts of the tribe they are in quest of, they go as near as may be considered safe and make a camp in some secluded spot, where they are not likely to be observed. Two clever men are now sent on ahead as spies, to make full and careful observations of the hostile camp, for the purpose of discovering in what part of it the man they are in search of has his quarters, the numerical strength of the tribe, any points of vantage, and so on.

During the time these spies are away reconnoitring the men who are left behind have marked a tree, and cleared the ground around it, as on the other occasions. They have painted their faces and chests white, with patches of the same colour on their upper arms. They have likewise built a bough screen around and above their little fire, to prevent its being seen at a distance after dark. This bough covering is made in the following manner: A few small saplings are cut and placed on end around the fire, which is in the centre. The cut ends of the stems of the saplings are inserted in the ground, with the upper or leafy extremities leaning against each other over the fire, in the form of a pyramid or cone. Another leafy bough is now placed in the apex, with the stem downwards, much in the same way that a keystone is used by stonemasons.

As soon as the spies obtain the first glimpse of the general camp of their adversaries, they crouch down in a depression in the surface of the ground, or hide among

bushes. They then begin to chant in low tones a song called 'guggarga,' which is believed to possess the magical gift of causing a smoke to ascend from the camp fire of the culprit, and thus disclose his location. During the continuance of this far reaching song, the men watch intently till they see a smoke issuing from a certain part of the camp. They then steal up closer to the encampment on the side indicated by the smoke, until they can recognise the man they are seeking, and note the position of his camp fire. Should the actual murderer not be present in the camp, then the spies identify the spot occupied by one of his elder brothers, or his father, who is then substituted to suffer in his stead.

When the messengers have located the doomed man, they return to their comrades, and report progress, with the usual formalities. After some refreshments have been partaken of, a few small pieces of wood are placed on the fire to make sufficient light for the men to see what they are doing. They all dance around the fire at which the chief conjurers are seated, singing in a very low tone, and working some enchantment upon the foe to render his chance of escape hopeless. After a while most of the men go to sleep, but there are always some of the old fellows on the watch. Some hours before daylight all hands are roused up, and they march noislessly away to the outskirts of the enemies' camp, holding small boughs in front of their bodies, so that they may not be observed. The song of the first bird which greets the dawn is the signal for the attack. The assailants divide, half of them marching off around one side of the camp, while the other half goes round the contrary direction, until they all unite on the opposite side of the camp, their meeting place being close to the intended victim.

The details of the onslaught are similar to those already narrated in the "Pirrimbir Expedition," to which the

reader is referred. When the victim falls, the avengers make a sudden charge upon him, and portions of his skin, flesh and fat are secured, the hands being sometimes cut off and carried away. If any of the man's friends interfere in his behalf, they render themselves liable to the same punishment. The invaders then retreat to their camping place of the night before, where they dance and spit around the marked tree, for the purpose of withdrawing the magic which it had absorbed from their former incantations and necromancy. After this they pick up any food or baggage which they had left there, and start on their homeward journey. On getting back to their own people, a full account is given of the result of the expedition.

Among the tribes herein referred to, the Magellanic clouds are supposed to be two native companions, the larger cloud being the cock bird, the smaller representing the hen. When these clouds are at their lower culmination, and consequently are not easily seen in thickly timbered country, the aborigines have a superstition that there is danger of neighbouring tribes organising a gurē party, to avenge some real or imaginary bloodshed. At such times, therefore, unusual vigilance is exercised by the young men, in watching the movements of their enemies.

Actinozoa	Heliolites (several species) Cyathophyllum ,, Pachypora Claudopora Zaphrentis
Spongida	Astylospongia
Brachiopoda	Orthisina (?)

The genus Halysites was found to be particularly abundant, and has been described by Mr. R. Etheridge, Junr., in the memoirs of the Geological Survey of N.S. Wales.[1] The limestone bed D referred to in this monograph, is the same as bed C on the accompanying section. The genus Endophyllum is very abundant in Bed A and very large coralla occur. One example measured quite 3 feet in length, 1 foot in height, and was of unknown width. This generic name is provisional, pending a detailed examination by Mr. Etheridge. No endeavour has been made to make specific determinations of the specimens of Favosites, Heliolites, Cyathophyllum, etc. Mr. Etheridge is at present engaged upon a monograph of the Silurian and Devonian corals, in which these specimens will be dealt with.

The limestone beds occurring in the N.E. part of the area mapped (portions 156, 196, 180, 136 parish of Barton) are of a somewhat different type. They are very thick and massive, attaining a thickness of at least 400 feet, and are built up mainly of crinoid stems and brachiopods, although corals are not uncommon. The following fossils were obtained from these beds:—

Trilobita	Bronteus sp. ind. Calymene ,, Encrinurus(?),,
Pelecypoda	—Conocardium Davidis, sp. nov.

[1] Palæontology No. 13. A monograph of the Silurian and Devonian Corals of N. S. Wales, Part I., the genus Halysites, by R. Etheridge, Jnr., Curator of the Australian Museum, Sydney.

Brachiopoda	Pentamerus Knightii, var. striata ,, Süssmilchii, sp. nov. Anoptotheca (?) australis, ,, Meristina (?) australis, ,, Atrypa, sp. ind. Rhynconella, sp. ind. Orthis (?) sp. ind.
Crinoidea	—Crinoid stems
Actinozoa	Favosites Pachypora Heliolites Tryplasma liliiformis

Several of the above are new to science and have been described by Mr. W. S. Dun, F.G.S.[1]

B. The Claystones (Slates)—These are similar in lithological characters to most of the so-called slates of Silurian age occurring in N. S. Wales, and possess no features of special interest. They appear in places to be more or less tuffaceous and have numerous beds of tuff associated with them. The topmost bed (*vide* section) contains numerous rounded fragments of limestone and rhyolite, probably ejected volcanic material. No fossils were found in any of these strata.

C. The Tuffs.—At the top of the Silurian formation, occurs a bed of coarse red tuff, 200 feet or more in thickness. It contains numerous red felspar crystals, but is too decomposed for microscopic examination. A good outcrop may be seen in Gap Creek (Portion 98). Here numerous thinly bedded cherty shales occur interstratified with the tuffs in such an irregular manner as to give them the appearance of being intrusive. (*Plate 16.*) This occurrence is apparently similar to those described from Lyndhurst[2] and Tamworth[3] by Messrs. David and Pittman. Near the top of

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[1] Rec. Geolog. Survey of N. S. Wales, Vol. VIII., part iii., 1906.

[2] The Mineral Resources of N. S. Wales by E. F. Pittman, A.R.S.M., p. 53, "The Auriferous Ore-beds of the Lyndhurst Goldfield."

[3] "On the Palæozoic Radiolarian Rocks of N.S. Wales," by Prof. T. W. E. David, B.A., F.R.S. and E. F. Pittman, A.R.S.M.—Quart. Journ. Geolog. Soc., London, 1899.

this tuff bed there are numerous rounded masses of rhyolite up to 10 feet in diameter, similar in character to that described below as outcropping on the Travelling Stock Reserve.

Besides this bed numerous other tuff-beds occur interstratified with the claystones and limestones. They range in thickness from less than an inch up to over 100 feet. They are for the most part very fine-grained *(Plate 17)*, light in colour, are perfectly stratified, and under the microscope are found to consist mainly of fragments of quartz, felspar, and minute particles of volcanic glass.

D. The Rhyolite.—This occurs as a large flow, outcropping on the Travelling Stock Reserve (No. 10191), at the junction of the Bowan Park and Cargo Roads.

Petrographical Description.—a. *Megascopic Characters.*

Colour, reddish-brown.
Fracture, even.
Crystallinity, aphanitic.
Granularity, porphyritic.
Minerals visible, felspar.

b. *Microscopic Characters.*

Texture
1. Crystallinity, hypohyaline, (largely glassy)
2. Fabric, porphyritic, with a groundmass largely glassy, but cryptocrystalline in part and exhibiting perfect flow-structure.
3. Grain-size of the phenocrysts 1·5 mm.

Minerals present, orthoclase, oligoclase, quartz.

The thickness of this flow could not be determined, but it is not less than 200 feet. Its position at the top of the Silurian strata, and the similarity of the rhyolite masses included in the red tuffs, point to the probability that these two formations belong to the same volcanic outburst.

IV. Devonian.

The following Devonian strata occur (in descending order)

1	Quartzites and sandstones	382 feet thick
2	Shale and sandstone (Lingula Beds) with Lingula, Spirifer, Rhynconella etc.	186 ,,
3	Massive red sandstones	200 ,,
4	Red and green shales...	304 ,,
5	Conglomerates with interbedded red shales and sandstones	412 ,,
	Total thickness	1484 feet

This represents only a portion of the original thickness of the Devonian formation, since much has been removed by denudation. Where Oaky Creek has cut its valley across these beds, only the lower 300 feet still remain.

The Basal Conglomerates.—These, with their associated bed of red shales and sandstones form the basal beds of the series. The conglomerates consist of waterworn pebbles of limestone, indurated shales, cherts, quartz, etc.; these range in size up to 4 inches in diameter, but the majority do not exceed 1½ inches. The cementing material consists of sand, clay, and ferric oxide. Some of the limestone pebbles contain recognisable fossil corals (Favosites and Heliolites), and were evidently derived from the Silurian limestones.

The Red and Green Shales.—These are thinly bedded and not fossiliferous; they display no features of special interest.

The Massive Red Sandstones.—These are coarse-grained, passing in places into conglomerate. The cementing material is largely ferric oxide, giving these strata a typical "old red sandstone" appearance. They frequently exhibit false-bedding, but contain no fossils.

The Lingula Beds.—These are a series of thinly-bedded shales and sandstones *(Plate 14)*, containing abundant evid-

ence of shallow-water conditions of deposition in the form of ripple-marks, worn-burrows, and current bedding. Near the base of these strata, a bed of shale occurs about 12 feet thick, and literally crowded with fossil brachiopods, including *Spirifer disjuncta*, *Rhynconella pleurodon* and *Chonetes*. Good outcrops may be seen in Gap Creek (portion 276, Parish of Barton) and in Coffee Hill Creek (portion 233, Parish of Bowan). Some 80 feet above the Spirifer bed is a thin bed of impure limestone, composed largely of the remains of a small brachiopod, *Lingula gregaria*. This species was first obtained by Rev. J. M. Curran and the writer, in Devonian rocks about 5 miles from Canowindra, where it occurs associated with Lepidodendron.[1] Specimens have since been obtained from the Devonian strata at Mount Lambie. *Lingula gregaria* would thus seem to have a fairly wide distribution in New South Wales Devonian rocks, and will probably prove useful in correlating strata of similar age from other localities in New South Wales. The best outcrop of the Lingula limestone is in Gap Creek (portion 276); another outcrop is in an unnamed creek on portion 277, where it contains also Rhynconella and Favosites (a small branching variety).

Quartzites and Sandstones.—These beds occupy the centre of the synclinal fold, into which the Devonian strata have have been bent, and are well exposed in Gap Creek. The beds of quartzite are very massive and many exhibit ripple-marking. The only fossil found was an impression of what appeared to be one of the plates of a placo-ganoid fish; unfortunately it was too imperfect for determination.

Relation of the Devonian to the Silurian Strata.—The best junction found occurs in Gap Creek (portion 98). At this point the dip of the basal Devonian bed is E. 10° S. at

[1] Rec. Austr. Mus., Vol. IV., part iii., "Lingula associated with Lepidodendron," by R. Etheridge, Junr.

about 54°, whereas the topmost bed of the Silurian strata (the Red Tuffs) dips in the same direction at an angle of about 65°. This would seem to indicate an unconformity between the two series. A reference to the accompanying section, however, will show that the Devonian beds, from the axis of the synclinal fold, where they are for a short distance horizontal, show a constantly increasing dip as the junction referred to is approached, while the dip of the Silurian strata increases beyond the junction until they become nearly vertical. Owing to the way in which the strata at the junction have weathered, and the absence in them of well defined bedding planes, the determination of the dip with any degree of accuracy is almost impossible. In the Oaky Creek section, further north, the Devonian conglomerates appear to rest conformably upon the Silurian tuffs, but here again the outcrops are not very satisfactory. The mere presence, at the base of the Devonian strata, of massive beds of conglomerate, indicates a pronounced uplift in the vicinity initiating a new cycle of erosion. The pebbles found in the conglomerates are all such as might have been derived from the Silurian strata. These facts point to a deforming movement having effected the Silurian strata prior to the deposition of the Devonian sediments with the resulting production of an unconformity.

Comparison with other New South Wales Devonian strata. —The best known Devonian strata in New South Wales are those occurring at Mount Lambie near Rydal; these consist mainly of shales, sandstone, and quartzites, and contain numerous fossils such as *Spirifer disjuncta*, *Rhynconella pleurodon*, *Lingula gregaria*, and *Lepidodendron australe*. These beds are generally referred to as being of Upper Devonian age.[1] At Back Creek near Braidwood,

[1] "Occurrence of Lepidodendron australe in the Devonian rocks of New South Wales," by Prof. T. W. E. David and E. F. Pittman. Rep. Austr. Assoc. Adv. Sci., Adelaide, Vol. v., (1893) pp. 397 - 404.

there occurs a series of conglomerates, sandstones, and shales, containing *Spirifer disjuncta*, *Rhynconella pleurodon*, and *Lepidodendron australe*, described by Prof. T. W. E. David,[1] who refers them to the Upper Devonian or Carboniferous Period. Mr. E. C. Andrews, B.A.,[2] has described a series of Upper Devonian quartzites, slates, conglomerates, etc. with associated volcanic rocks containing Lepidodendron from Yalwal, N.S.W. A somewhat different occurrence is that near Tamworth, described by Prof. T. W. E. David and E. F. Pittman.[3] These beds have a thickness of over 9,000 feet, and consist of claystones, radiolarian cherts, tuffs, radiolarian limestones and coralline limestones. *Lepidodendron australe* is abundant in the tuffs and claystones, while the coral limestones contain Diphyphyllum, Alveolites, Heliolites, Favosites, Syringopora, Cystiphyllum, etc.; these corals are referred by Mr. R. Etheridge to the Middle Devonian epoch. Lastly we have in the Yass District, the Murrumbidgee beds consisting of a thick series of claystones and limestones, and containing abundant fossils, including *Spirifer Yassense*, *Chonetes Culleni*, *Diphyphyllum gemmiforme*, Syringopora, Favosites, Cyathophyllum, *Cystiphyllum australicum*, *Receptaculites australis*, Stromatopora, etc.[4] These beds are generally referred to the Middle Devonian epoch.

It will be seen that both in their lithological characters and in their contained fossils, the Devonian strata described in this paper, closely resemble the Mount Lambie and the

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[1] "Contribution to the Study of Volcanic Action in Eastern Australia," by T. W. E. David, B.A., F.G.S. Proc. Austr. Adv. Sci., 1893.

[2] Report of the Yalwal Goldfield, by E. C. Andrews, B.A., Mineral Resources, No. 9, Dept. Mines and Agric., Geol. Sur., N.S.W.

[3] "On the Palæozoic Radiolarian Rocks of N. S. Wales." by Prof. T. W. E. David, B.A., F.G.S., and E. F. Pittman, A.R.S.M. Quart. Journ. Geol. Soc. London, Vol. LV., 1899.

[4] "On the occurrence of a bed of fossiliferous tuff and lavas between the Silurian and Middle Devonian at Cavan, Yass," by A. J. Shearsby. Proc. Linn. Soc. N.S,W., Vol. XXX., part 2.

Braidwood beds, both of which are generally considered, mainly on the presence of *Lepidodendron australe*, to be of Upper Devonian age. If we take the Canobolas beds as being of this age, it becomes necessary to account for the absence of the middle and lower Devonian strata (this applies also to the Mount Lambie and Braidwood districts). There are two possible explanations: (1) the Lower and Middle Devonian strata had been *entirely* removed by denudation prior to the deposition of the Upper Devonian, or (2) the areas where the Upper Devonian now occur were dry land during the Lower and Middle Devonian epochs. Both suppositions, but particularly the former, demand a long interval of time between the close of the Silurian and the beginning of the Upper Devonian, during which there must have been profound denudation and corresponding deposition elsewhere. Much might be said both for and against these two explanations, but in view of our present scanty knowledge of the Devonian strata of New South Wales, it is perhaps premature to endeavour to arrive at any definite conclusions. There is one other possible explanation that appears worthy of consideration. So far as the writer knows, wherever the so-called Upper Devonian strata occurs in New South Wales there is an absence of Middle Devonian strata, and conversely, where so-called Middle Devonian strata occur, such as the Murrumbidgee beds, there appears to be an absence of Upper Devonian beds. Might not these two types of Devonian strata be contemporaneous, the lithological and palæontological difference being due to the different conditions under which each was deposited; the Murrumbidgee beds being deposited in a more or less open sea, far removed from a shore line and containing an abundant coral fauna, while the beds of the Canoblas, Mount Lambie type, were deposited in a shallow coastal sea, which was receiving abundant and relatively coarse sediment from the adjacent land.

V. The Volcanic Series.

It is not intended to give any detailed description of these rocks in this note. They form portion of the immense accumulation of lavas and tuffs which go to form the group of extinct volcanic peaks known as the Canoblas mountains. They consist, in the area mapped, mainly of basalt flows, but andesites, and andesitic and trachytic tuffs also occur, particularly towards the Canoblas. These deposits are everywhere unconformable with the underlying Silurian and Devonian strata, and are most probably of Tertiary age.

VI. Summary.

The nature of the Silurian sediments indicates tranquil deposition in an open, comparatively shallow sea, considerably removed from any shore line, and accompanied by a slow, intermittent subsidence. Towards the close of the period vulcanism became an important feature, as evidenced in the thick beds of tuff and rhyolite.

The Devonian sediments, on the other hand, indicate shallow water conditions of deposition, with dry land in the immediate vicinity to provide the coarse sediments of which most of the strata are composed.

With the close of the Silurian Period, a deformative movement, perhaps already heralded by the pronounced vulcanism, began to affect the earth's crust, resulting probably from the stresses in the earth's body accumulated during the long continued sedimentation which marked the Silurian period. This resulted in the elevation of portions, at least, of the Silurian sediments into dry land, with the initiation of a new cycle of erosion. This deformative movement probably continued more or less throughout the Devonian period, and culminated in the great mountain building of the Carboniferous period, when all the Silurian and Devonian strata were folded into a great series of

anticlinal and synclinal folds of which only the remnants are now available for study. Since the Devonian period, there is no evidence of this part of New South Wales having ever again been beneath the sea.

In conclusion I have to acknowledge the assistance given me in the field work by several of my students at the Sydney Technical College, and by Mr. E. A. Perry. I am also inbebted to Prof. T. W. E. David for much kindly advice and assistance.

BIBLIOGRAPHY OF AUSTRALIAN, NEW ZEALAND, AND SOUTH SEA ISLAND LICHENS.

(Second Paper.)

By Edwin Cheel.

(Communicated by J. H. Maiden, F.L.S.)

[*Read before the Royal Society of N. S. Wales, December 5, 1906.*]

Since the publication of the "Bibliography of Australian Lichens," in this Journal, Vol. xxxvii., pp. 171 – 182, 1903, I have received, through the kindness of M. Gustave Beauverd, the Curator of Herbier Boissier, Chambèsy, Geneva, some additional works by the late Dr. Jean Müller on Australian Lichens. In Dr. Müller's works, students of Australian Lichens are often referred to works by various authors on New Zealand and South Sea Island lichens, for descriptions of Australian species. For the benefit of those who may be interested in the Lichen Flora of Australia I have thought it advisable to submit this, as a supplement, and at the same time to extend the title, so as to embrace the works treating on the Lichen Flora of the adjacent islands

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ANALYSES OF CHOCOLATE SHALE AND OF TUFACEOUS SANDSTONE FROM THE NARRABEEN SERIES.

By S. G. WALTON, Junior Demonstrator, University of Sydney. With a Petrological Description by R. S. BONNEY, B.A.

(Communicated by Professor LIVERSIDGE, F.R.S.)

[*Read before the Royal Society of N. S. Wales, December 5, 1906.*]

THE following analyses were made in the Chemical Laboratory of the University of Sydney, at the request of Prof. Liversidge, in connection with an investigation upon the distribution of gold in small quantities in rocks and natural waters. The weathered chocolate shale from Long Reef, near Manly was selected for examination because it showed stains of copper. The specimens were kindly supplied by Prof. David, F.R.S. The Tufaceous Sandstone from Rose Bay was obtained from a bore at a depth of 1900 feet, and the Chocolate Shale from Long Reef near Manly.

	Sandstone.	*Shale.*
SiO_2	61·65	38·98
Al_2O_3	13·29	28·00
Fe_2O_3	2·94	14·39
FeO	6·44	0·98
Cr_2O_3	0·13	0·06
MnO	0·60	0·04
NiO	trace	0·01
CaO	absent	absent
CuO	0·01	0·11
PbO	absent	absent
ZnO	absent	absent
MgO	3·44	0·36
BaO	0·08	trace
CaO	1·64	0·15
Na_2O	2·44	0·08
K_2O	0·66	0·18
H_2O − (at 110° C.)	1·30	3·60
H_2O + (above 110° C.)	4·02	10·38
CO_2	0·90	0·22
TiO_2	0·97	2·05
ZrO_2	0·01	0·01
P_2O_5	0·05	0·06
SO_3	0·03	0·01
Cl	0·01	0·15
F	absent	absent
S (FeS_2)	0·04 S = FeS_2 0·07	0·05 S = FeS_2 0·09
SrO	absent	absent
Li_2O	absent	absent
Sum	100·68	99·91
Less O for Cl		0·04
Sum		99·87
Specific gravity	2·693	2·685

The methods followed and quantities of reagents used were those detailed by Hillebrandt and Washington. Each estimation was made in duplicate, and only the purest of reagents were used, which were all tested, and where necessary, as in the case of calcium carbonate, specially purified. I regret being unable, through want of time, to estimate the amount of vanadium present. I am indebted to Mr. R. S. Bonney, B.A., of the Geological Laboratory, Sydney University, for the following descriptions of the specimens:

Tufaceous Sandstone.—This rock belongs to the Narrabeen beds, and is a green tufaceous sandstone containing small rounded pebbles of green and red chert. As seen in this section the fragments composing the rock are rounded and subangular in outline.

The chief constituents are:—1. Subangular fragments of quartz and felspar. 2. Fragments of decomposed igneous rocks, some grains of which contain numerous small felspar laths. There is one small grain of micrographic granite in the slide that was prepared. 3. A green chlorite decomposition product occurring plentifully throughout the slide. It appears partly in the form of grains, mostly rounded; partly as a very narrow border due to *secondary decomposition*, (*not* marginal decomposition) round all the other fragments, quartz included; and occasionally as an interstitial infilling. This mineral is very common in the Narrabeen rocks, but never occurs in the Hawkesbury Sandstones. 4. Small round grains and pebbles of green and red chert. Bands of coloured chert pebbles are of very common occurrence in the lower half of the Narrabeen rocks. The thin section reveals a great variety of constituents, but most of them are included in the above four classes. Siderite, which is usually plentiful in the Narrabeen rocks, is not present in this slide.

Chocolate Shale.—This is a fragment of chocolate shale and was obtained from Long Reef near Manly, where the chocolate shales outcrop on the sea shore. It is a dark reddish-brown ferruginous looking specimen of fine muddy shale. It displays a slight shaly cleavage but easily crumbles to pieces in all directions. Beyond this no definite structure is visible in the hand specimen. There are a few small greenish spots stained with copper. This specimen is very much weathered, and accordingly differs in appearance from the perfectly fresh chocolate shale, such as that obtained from the Balmain Coal Mine in the course of shaft sinking. It is probable that there is a corresponding difference in the composition, so that an analysis of the unweathered shale would, in all likelihood, differ materially from the present one.

The unweathered shale is a clean rich chocolate coloured shale, composed of very fine impalpable material. It possesses a very indifferent shaly cleavage, and for the most part crumbles to pieces on exposure to the air. A transparent section of the fresh shale when seen under the microscope generally reveals a number of small concretionary blebs of siderite scattered through the fine, reddish-brown, homogeneous ground mass; these small concretions often exhibit a radial structure, and may be present in great numbers or be almost absent. Hence in rock that has not been weathered and oxidised, the proportion of carbon dioxide would probably be greater.

THE RATE OF DECAY OF THE EXCITED RADIO-ACTIVITY FROM THE ATMOSPHERE IN SYDNEY.

By S. G. LUSBY, B.A. and T. EWING, B.Sc.
(Communicated by Prof. POLLOCK.)

[*Read before the Royal Society of N. S. Wales, December 5, 1906.*]

IN connection with an investigation, still in progress, it was considered necessary to find the rate of decay of the excited radioactivity from the atmosphere in Sydney. Although the work consisted merely of a repetition of an experiment of Allan,[1] following work of Rutherford,[2] Elster and Geitel,[3] and Rutherford and Allan,[4] the result may be of some interest as no determination of the constant made in Australia has, so far as we know, been published. The facts are here separately recorded as the main research is no longer directly concerned with the matter.

A copper wire, ten metres in length was suspended vertically in the tower of the Physical Laboratory of the University; it was kept negatively charged by a Wimshurst machine, the potential being about 25,000 volts. After about three hours exposure, the wire was removed and rubbed with cotton wool moistened with ammonia. The cotton wool was then incinerated in a platinum crucible and the ashes tested for radioactivity in the usual way. A Dolezalek electrometer was used and the whole of the apparatus screened from outside electrostatic influence. The observations were commenced about 15 minutes after the wire was discharged, the activities being measured in terms of scale divisions per second.

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1 Phil. Mag., Feb. 1904. 2 Phil. Mag., Feb. 1900, 3 Phys. Zeit., iii. and xl,, 1901. 4 Phil. Mag., Dec. 1902.

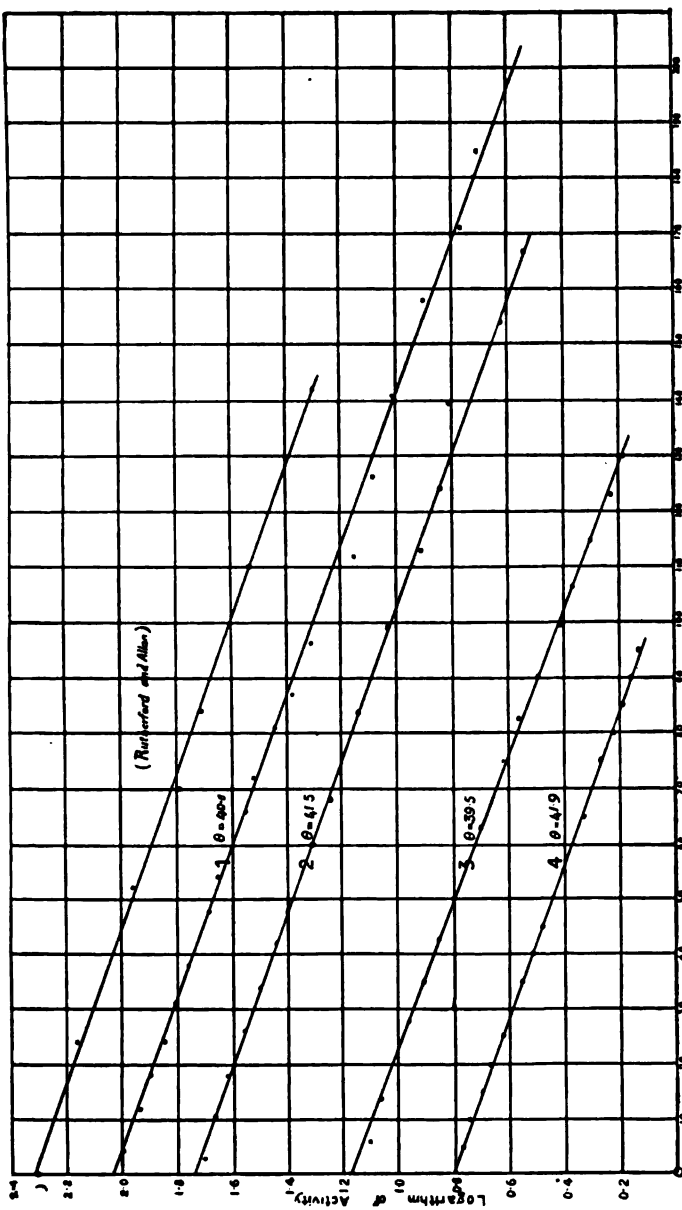

Fig. I.—RATE OF DECAY OF THE RADIO-ACTIVITY FROM THE ATMOSPHERE IN SYDNEY.

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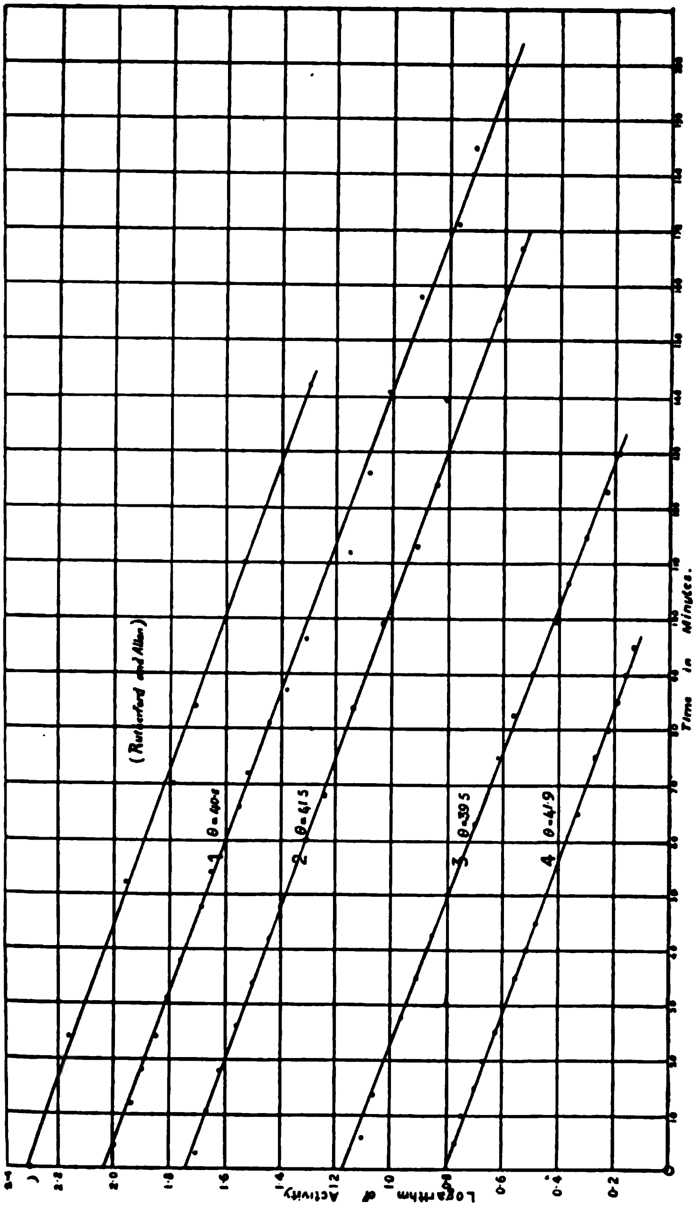

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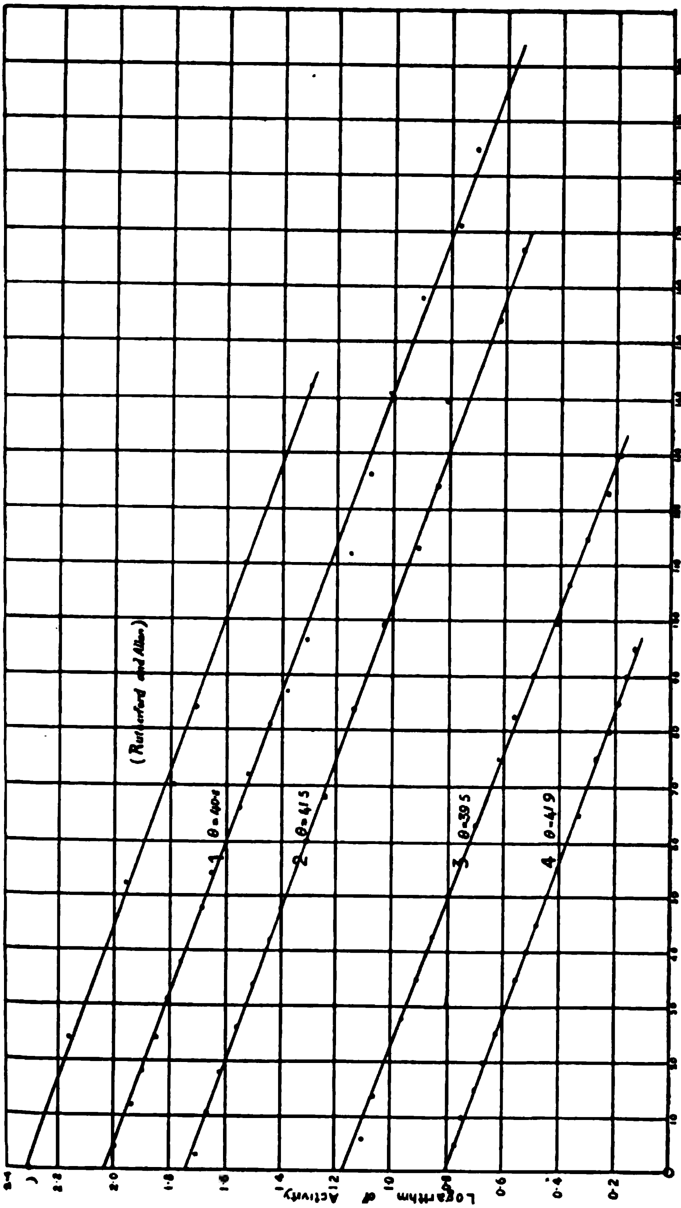

The RATE of DECAY of the EXCITED RADIO-ACTIVITY from the ATMOSPHERE in SYDNEY.

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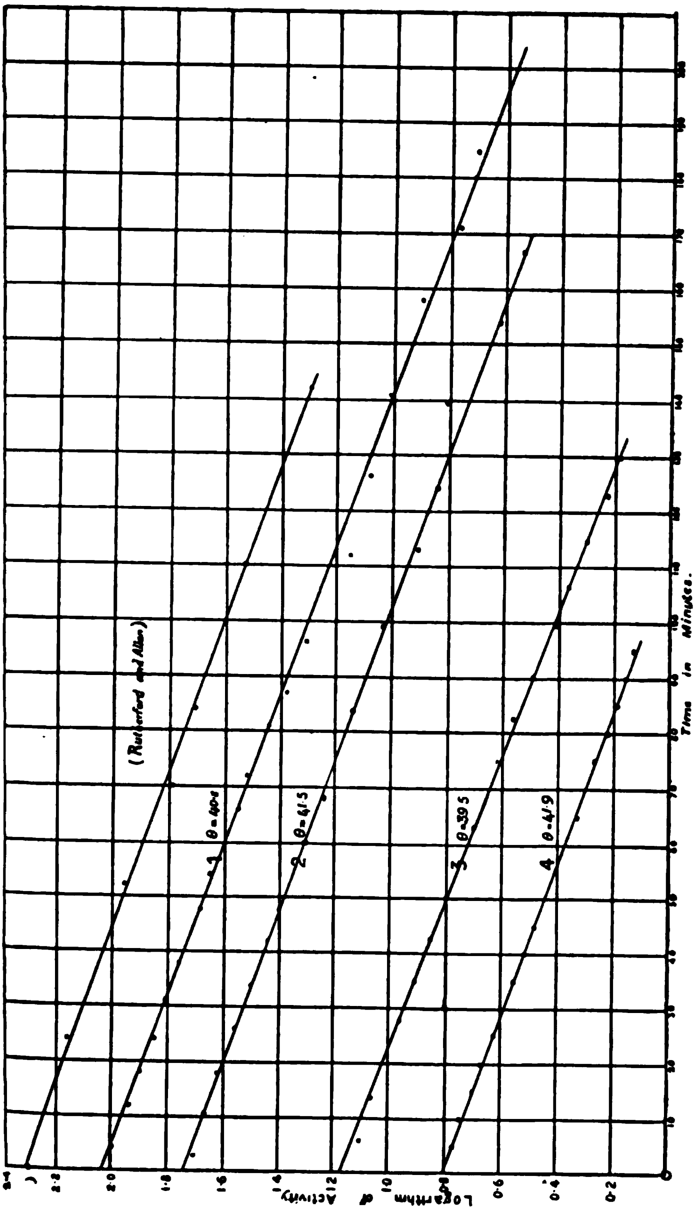

Fig. I.—RATE OF DECAY OF THE RADIO-ACTIVITY FROM THE ATMOSPHERE IN SYDNEY.

To exhibit the results the common logarithms of the activities have been plotted against time in figure 1. In each case a straight line best fits the points, showing that the rate of decay, for the interval of time during which observations were made, follows an exponential law. The results of four experiments are shewn, the times for the activity to fall to half value being as follows:—

1. December 16th, 1905 ...	40·7	minutes
2. December 14th, 1905 ...	41·5	„
3. December 20th, 1905 ...	39·5	„
4. December 18th, 1905 ...	41·9	„

For comparison, values given by Rutherford and Allan[1] for a lead wire exposed in an attic in Montreal, are plotted on the same diagram; in this case the time for the activity to fall to half value seems to be 41·7 minutes rather than 45 minutes as stated in the paper quoted. All these estimates of the time for the activity to fall to half value agree very closely with those given by Bumstead in a paper in the American Journal of Science for July 1904, where the question of atmospheric radioactivity is discussed at length.

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[1] Phil. Mag., Dec. 1902.

GOLD NUGGETS FROM NEW GUINEA SHOWING A CONCENTRIC STRUCTURE.

By A. LIVERSIDGE, LL.D., F.R.S., Professor of Chemistry in the University of Sydney.

[With Plates XII., XIII.]

[Read before the Royal Society of N. S. Wales, December 5, 1906.]

THE two small nuggets referred to in this note were received from New Guinea; they show the usual water-worn appearance externally. The assays made at the Royal Mint, Sydney, gave for No. 1 nugget weighing ·90 oz. gold 8895, and silver 100 parts. No. 2 nugget weighing ·86 oz. gave gold 8825 and silver 105 parts.

When sliced, polished and etched with aqua regia, small enclosures of hæmatite and quartz, also cracks and cavities, become visible, but the usual macro-crystalline structure of gold is absent. Parts, however, near the edges possess a clearly marked concentric structure.

As stated in the first paper upon this subject,[1] this is the structure I then thought might be found; but out of the large number of nuggets examined for several years past, these two are the only ones in which I have been able to detect any indication of a concentric structure. Hence these nuggets are so far unique.

It will be noticed that the section shows indentations which look like foldings or involutions. I do not think, however, that these are due to portions of the nuggets having been bent over, driven in, or welded on by impact; but it looks as if the gold, especially where it shows this

[1] See this Journal, Vol. XXVII., 1893, and Chemical News, 1894.

concentric structure, might have been deposited either upon a nucleus of, or upon the interior walls of a cavity, in the same way that agates have been formed by the deposition of silica and chalcedony. From the way in which the contour lines at *a* and *b* run parallel with the sharp angle at *c* (*Plate 12*) and then suddenly flatten out to the left, renders it I think, unlikely that the nugget was built up about a nucleus, but it is easy to understand that the layers may have followed the irregularities of a cavity. The more central parts do not show any lines of deposition.

It is also noticeable that these two nuggets do not in any part show any undoubted crystalline structure; when examined under the higher powers, (in *Plate 13* the enlargement is 50 diameters) they, on the contrary, present a somewhat spongy or cellular appearance, although the portions which look like cavities are really solid; the gold in these parts may have been deposited in a spongy or cellular form, and the interstitial spaces afterwards filled in. The photographs are taken from the smaller nugget, the larger one shows the concentric structure much less well marked and is hardly traceable.

ANALYSES OF ROMAN GLASS FROM SILCHESTER, WITH SPECIAL REFERENCE TO THE AMOUNT OF MANGANESE AND IRON PRESENT.

By C. J. WHITE, Caird Scholar, University of Sydney.
(Communicated by Professor LIVERSIDGE, F.R.S.)

[*Read before the Royal Society of N. S. Wales, December 5, 1906.*]

[**Introduction.**—The following analyses of Roman glass have been made under my direction by Mr. C. J. White, Caird Scholar, in the Chemical Laboratory of the University of Sydney, mainly with the object of ascertaining if possible whether manganese peroxide had been purposely used in its preparation, and partly because the amount of manganese in Roman glass is not given in the analyses contained in the principal books of reference.

The material consisted of about 8 ounces of fragments of Roman glass found in 1896, during the excavations on the site of the Roman city at Silchester) between Basingstoke and Reading, Hampshire, England), which I had obtained for the purpose of examination from Mr. W. H. St. John Hope, the Assistant Secretary of the Society of Antiquaries. The fragments consisted mainly, if not entirely, of portions of bottles. The glass for the most part is of a dull greenish colour, somewhat blebby, and most of it shows the usual iridescent scale due to superficial decomposition. The hardness of undecomposed surfaces was found to be slightly greater than that of ordinary English window glass, that is, some of this Roman glass will just scratch window glass, but the difference in hardness is not very great, nor is it a matter of much importance.

The presence of manganese is of interest, because pyrolusite may have been added to counteract the green colour

due to the presence of ferrous silicate, *i.e.*, to whiten the glass; the name pyrolusite is given to the black oxide of manganese on account of this property, and the French call it "Savon des verriers" for the same reason; it has been employed for this purpose from the earliest times, and its use is mentioned by Pliny. The manganese peroxide acts partly by oxidising ferrous silicate to ferric silicate, which possesses much less tinctorial power than the former, and partly by the amethyst colour of the manganese silicate (which is complementary in tint) neutralizing the green. The presence of manganese in glass can often be seen by the amethyst tint which window glass acquires when exposed to the sun's rays, and it is also seen in fragments of tumblers and other ware made of flint glass, which have been thrown out and left exposed to the sun. This change in colour is due to the green ferrous silicate having been converted into the reddish ferric silicate; the amethyst colour of the manganese silicate is then no longer neutralized, and accordingly the glass shows a more or less deep purple tint.

Average Sample.—The first analysis was made upon some fragments of the mixed glass, without any selection according to colour; a fair amount of manganese was found to be present.—(See analysis A.) It was next thought desirable to analyse samples of the almost colourless, and of the deeper green coloured fragments, to ascertain whether the manganese has been added in the former in sufficient quantity to whiten the glass, or whether it had been made from purer materials.

Colourless glass.—Some of this was in fairly flat pieces, like window glass, and had a dull surface somewhat resembling that of ground glass; other portions were fragments of vases or bottles. Although here termed colourless for distinction, it shows a pale green tint when viewed

sideways. This glass contains less iron than the above, the amount of manganese is correspondingly small; the materials were probably specially selected.—(See analysis B.)

Green glass.—Fragments were picked out showing a fairly deep bluish-green tint; they contained many blebs and consisted apparently of pieces of the necks, handles, and bottoms of bottles or vases.—(See analysis C.)

From these three analyses it is impossible to say definitely whether manganese was purposely added or not, it probably was, but it may have been naturally present in the materials used. The question requires further investigation.—A. LIVERSIDGE.]

Method of Procedure.—In the general analysis the methods of Washington[1] and Hillebrand[2] for a naturally occurring silicate were adopted in the main. The more important features may be briefly indicated.

Specific Gravity.—The specific gravity of two fragments of Specimen A, was found by a Jolly balance, the results being 2·49 and 2·50 respectively. Check determinations by the ordinary balance gave 2·493 and 2·499.

Total Water.—For this determination Penfield's[3] method was employed. It consists essentially in igniting the powdered substance in a narrow glass tube closed at one end—condensing the moisture on the cooler part of the tube—drawing off this portion and weighing it, with and without the moisture. The results obtained were very consistent (the greatest difference being ·02% in a series of four) and the many possible sources of error of the old 'loss on ignition' method seem to be avoided.

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[1] Washington—Manual of Chem. Anal. of Rocks, 1906.

[2] Hillebrand—"Some Principles and Methods of Rock Analyses," Bull. U.S. Geolog. Sur., 176, 1900.

[3] S. L. Penfield—Amer. Journ. Sci., XLVIII., p. 31, 1894.

Silica.—In place of a single evaporation followed by heating to 120° the double evaporation recommended by Hillebrand[1] was employed, the second was found to account for about ·2% silica. The purity was tested by hydrofluoric acid and the small quantity of Fe etc. carried down was treated in the usual way.

Ferrous Iron—Here the method devised by Cooke[2] was employed, *i.e.*, the finely powdered substance was heated with HF and H_2SO_4 on a water bath and in an atmosphere of carbon dioxide, then cooled and titrated with potassium permanganate.

Manganese.—The presence of manganese was indicated by the colour of the mass after fusion, but owing to the delicacy of this test and also to the fact that sulphuretted hydrogen failed to bring down any precipitate in 20 minutes (volume of solution = 500 cc.) manganese was thought to be present only as a trace. Consequently in the first analysis (rejected) its estimation was neglected. However the discolouration of lime combined with a shortage of ·5% in the total, caused special precautions to be taken in the two succeeding analyses. Of all the methods tried for the iron manganese separation the most satisfactory was the ordinary one by ammonia (three precipitations). The manganese was precipitated by evaporating the solution to less than 200 cc., passing sulphuretted hydrogen and then allowing to stand in a corked flask over night; it was eventually weighed as Mn_3O_4. The presence of alumina with such small quantities of iron and manganese seemed to vitiate the basic acetate method and the barium carbonate method of Treadwell[3] was found to be cumbersome. A colorimetric method recently proposed[4] was found to give

[1] Hillebrand, p. 52.
[3] Treadwell (Hall)—Quantitative Analysis, p. 121.
[2] J. G. Cooke—Amer. Journ. Sci., (2) XLIV., p. 347, 1867.
[4] Nazareno Tarugi—Gazzetta, 1906, p. 332. Abstract in Journ. Chem. Soc., 1906, p. 631.

very fair results and is specially applicable to samples in which the manganese percentage is very low.

The Alkalies were determined by the Lawrence Smith method,[1] *i.e.*, by converting to chlorides by heating with calcium carbonate and ammonium chloride and then separating the two alkali chlorides with hydroplatinic acid.

The remaining constituents, were determined by the ordinary methods and call for no special comment.

SUMMARY OF ANALYSES.

			I.	II.	Mean
Hygroscopic	H_2O	...	·40	·42	·41
[1]Combined	H_2O	...	·00	·00	·00
	SiO_2	...	69·85	69·67	69·76
	Al_2O_3	...	1·89	1·94	1·92
	[2]FeO	...	·71	·77	·74
	Fe_2O_3	...	·16	·18	·17
	MnO	...	·70	·61	·65
	CaO	...	7·09	7·08	7·08
	MgO	...	1·11	1·07	1·09
	Na_2O	...	17·34	17·72	17·53
	[3]K_2O	...	·59	·58	·59
Totals	...	...	99·84	100·04	99·94

[1] Penfield's method. [2] Cooke's method. [3] Lawrence Smith's method.

Since the specimen (*A*) had a greenish tinge, due to iron, the obvious inference was that if manganese had been added purposely as a decolouriser then not quite enough had been used. In the nearly colourless variety (*B*), it was expected that the manganese had neutralised the effect of the iron and therefore that the ratio of manganese to iron would be greater than in (*A*). In the bluish-green variety (*C*), similarly a large excess of iron was expected. The analyses

[1] J. L. Smith—Am. Journ. Sci., I., p. 269, 1871.

did not bear out these surmises, in fact the nearly colourless glass (*B*) was found to have relatively slightly less manganese than either *A* or *C*. Still it is quite possible for one and the same quantity of iron to require different quantities of manganese to decolourise it (according to the state of oxidation of the two in the raw materials and the conditions of fusing) since the action of pyrolusite depends on two factors—(1) its oxidising action, (2) its power of forming a silicate complementary in colour to that of iron silicate. Also specimen *B* was of much finer quality than *C* and hence it is probable that pains would be taken to secure such conditions in fusing as would be most conducive in producing a colourless glass. In commoner varieties, where colour is no object, it is not likely that such trouble would be taken, and it is possible for a specimen of glass to contain quite a large percentage of manganese and yet retain a green colour due to ferrous silicate if a reducing atmosphere is maintained throughout the fusing process.

Also it is rather hard to see how manganese could be present as a mere impurity to the extent of ·5 to 1·5%. According to Pliny the Romans employed sand and Egyptian soda (from sea weeds) in glass making; the latter would account for the presence of iron and calcium as well as the preponderance of soda over potash, but not for the manganese, and one would scarcely expect to find 1% of manganese in sand. However, there is not sufficient information available to definitely prove or disprove that manganese was purposely added, the question therefore remains an open one.

Complete analyses of *B* and *C* were not made, iron and manganese only were estimated, these were obtained in solution by treating with hydrofluoric acid and then evaporating down with sulphuric acid.

The results obtained were:—

	1	2	3	4	Mean	[Colorimetric methods
(A) Mixed sample.						
FeO	[·86]	·93	·93	·92	·93%	
MnO	·70	[·61]	·72	·69	·70%	·67%
(B) Colourless glass						
FeO	·72	·73	·70	...	·72%	
MnO	[Solution lost]	·5	·53	...	·51%	·48%
(C) Dark bluish-green						
FeO	1·31	1·26	1·30	...	1·29%	
MnO	1·39	1·34	1·40	...	1·38%	1·28%]

From the foregoing analyses it is evident that the Silchester glass (*A*) does not differ materially in composition from a modern English crown glass, and more nearly still approximates that of a Roman bottle analysed by Benrath; it is however very different from a modern bottle glass.

For the sake of comparison some analyses of glasses of similar composition to this Silchester,[1] are appended:—

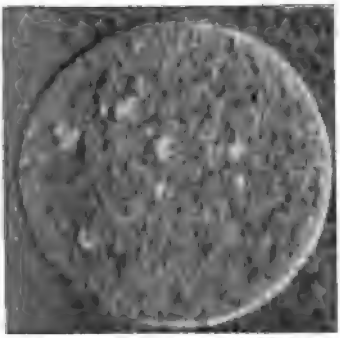
	A	B	C	Old Egyptian	Roman bottle	English window
H_2O	·41					
SiO_2	69·76	...	...	72·30	70·66	70·71
Al_2O_3	1·92	...	...	1·19	2·25	
FeO	·74					1·92
Fe_2O_3	·17	·72	1·29	·59	1·24	
MnO	·65					
CaO	7·08	...	...	5·17	8·38	13·38
MgO	1·09					
Na_2O	17·53	...	...	20·83	17·17	13·25
K_2O	·59					
Totals	99·94			100·08	99·70	99·26

[1] Analyses by Benrath, quoted by Roscoe and Schorlemmer, Metals, p. 473.

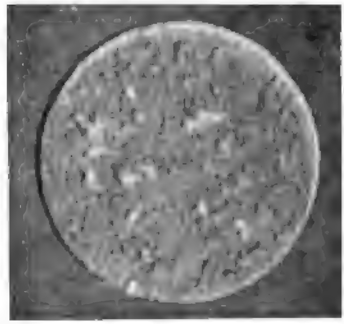
In connection with this work I beg to acknowledge my indebtedness to Professor Liversidge for his valuable suggestions and kindly encouragement as well as for the use of his interesting specimens.

TEST-PIECES TREATED ON THE SAND-BLAST APPARATUS.

During 2 minutes under 45 lbs. per square inch steam pressure.

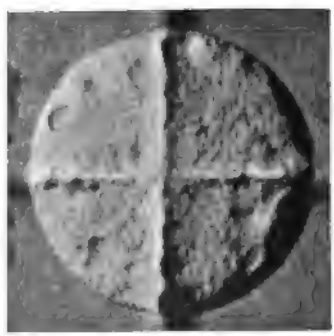


Granite.

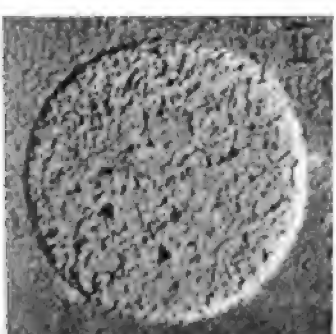


Melaphyr.

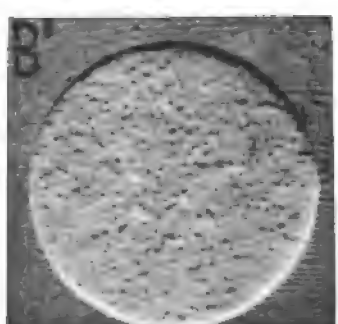
Sandstone.



Cement Slab.



Artificial Stone.



Blast-furnace Slag.

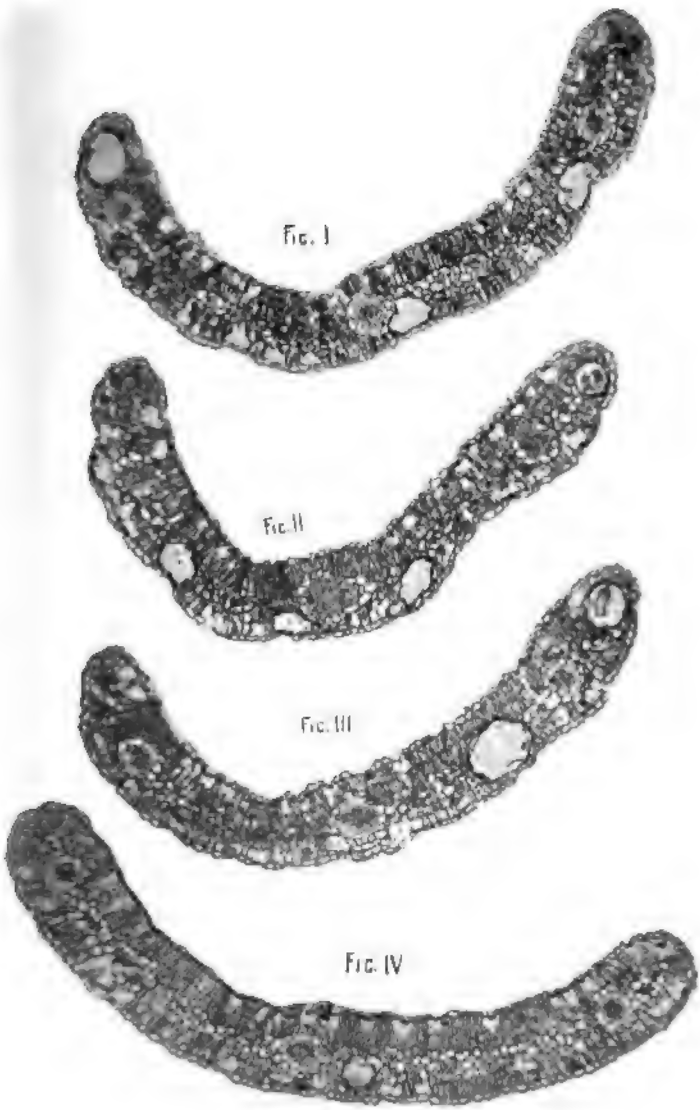
Fig. 1. "Tuber" of Native Vine.

Fig. 2.

Fig. 3.

Sections of Native Vine "Tubers."

c



Melaleuca thymifolia, ***Sm.***

Trans. sect. fol. × 50.

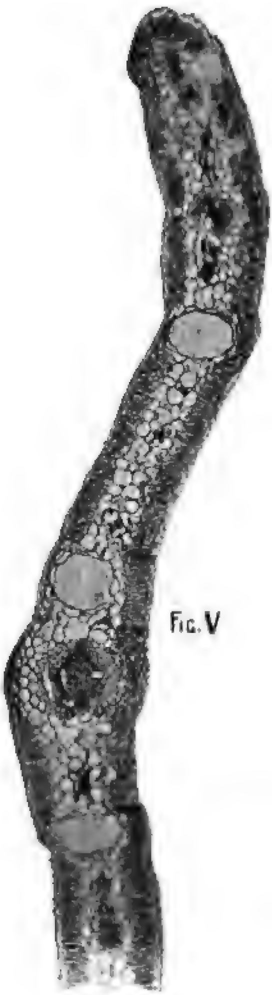


Fig. V

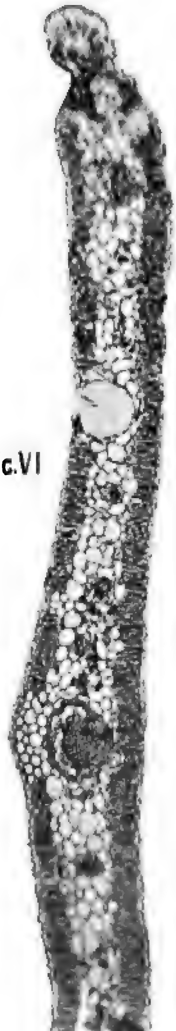


Fig. VI

Melaleuca linariifolia, *Sm.*

Trans. sect. fol. × 70.

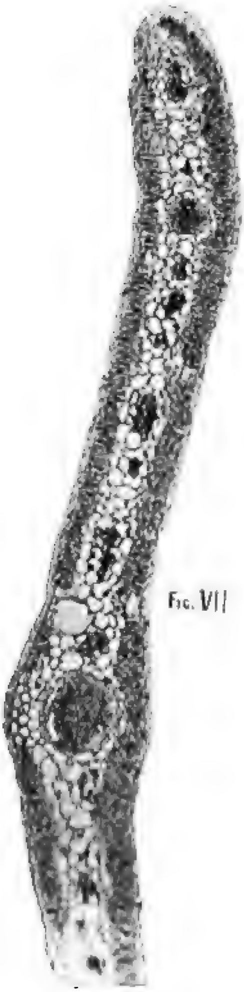


Fig. VII

Fig. VIII

Melaleuca linariifolia, ***Sm.***

Trans. sect. fol. × 70.

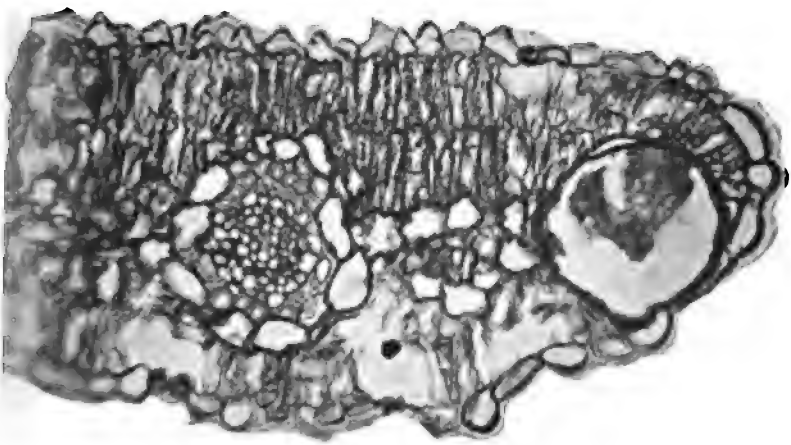


Fig. IX

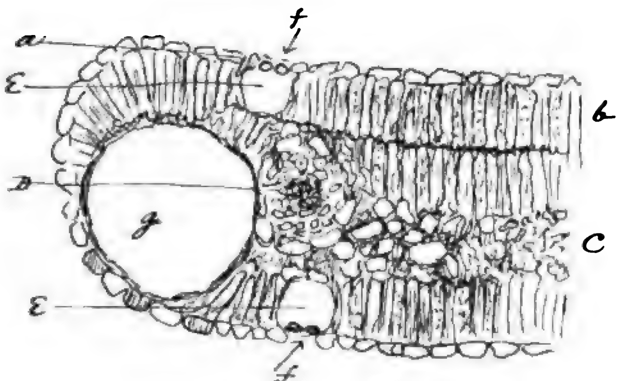


Fig X

x 200

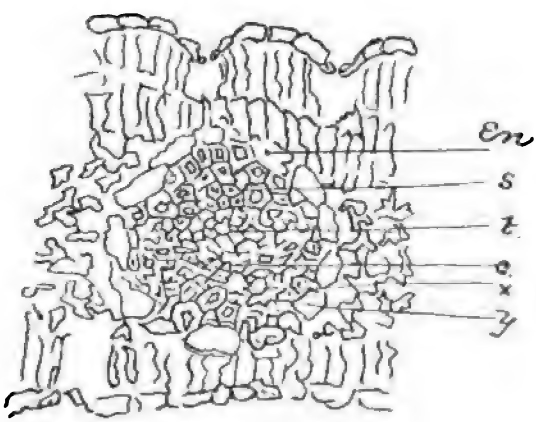


Fig XI

x 200

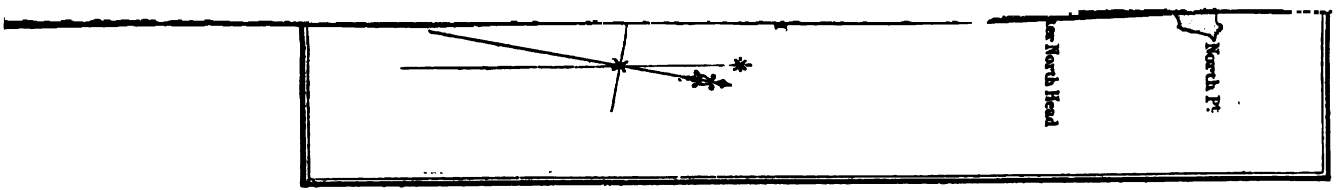
Melaleuca thymifolia, *Sm.*

Plate VIII.

X.

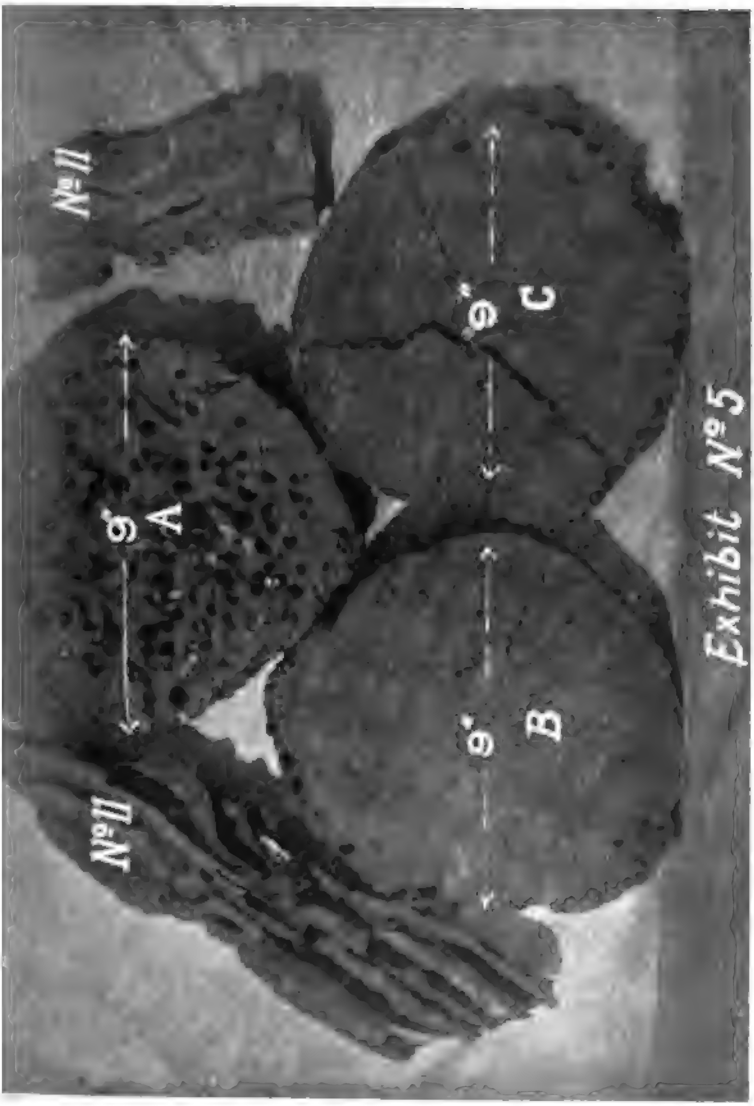
Nos. 11 are portions of timber from a Northern River, and show large diameter of *Cobra* holes compared with local experience.

ate VIII A.



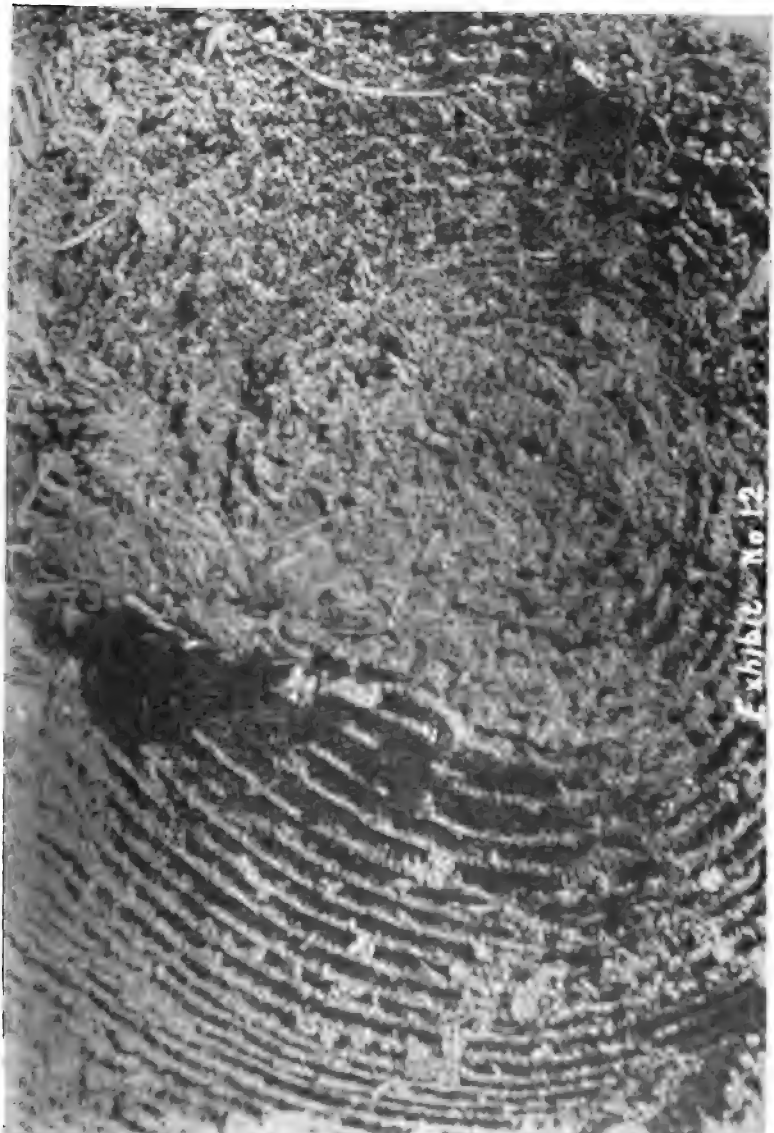
X.

Nos. 11 are portions of timber from a Northern River, and show large diameter of *Cobra* holes compared with local experience.

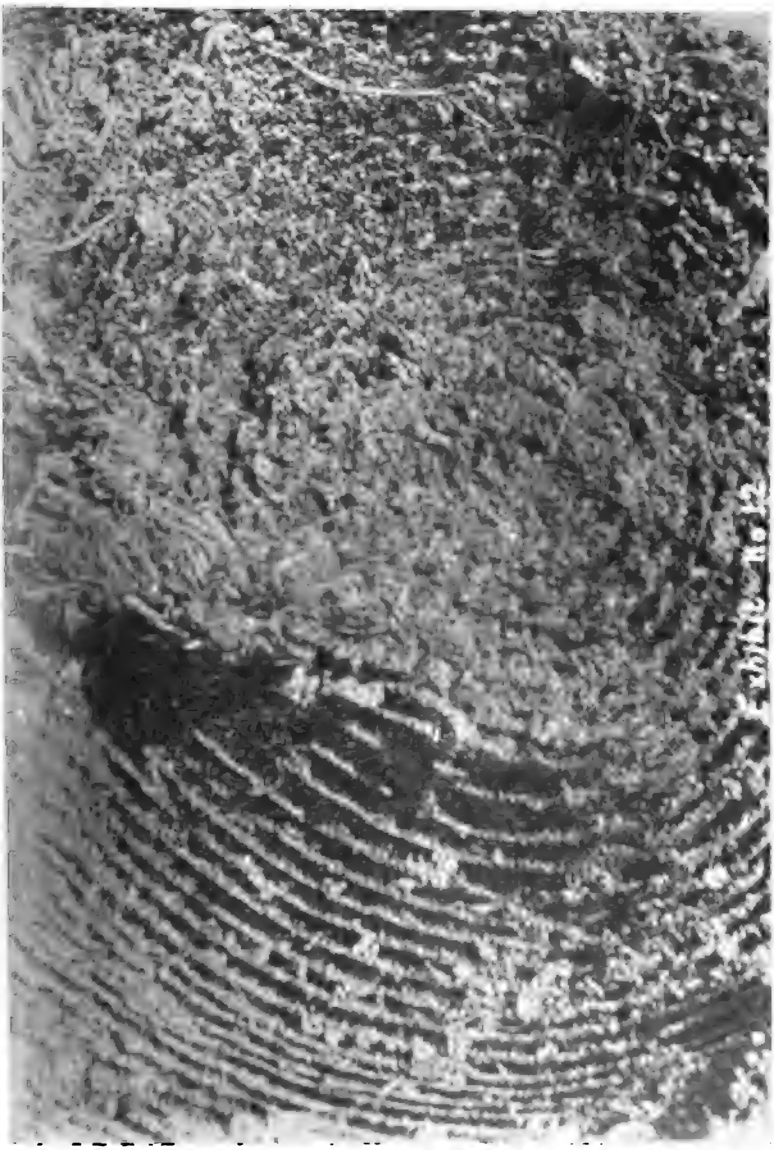


A, B and C—Sections of piles taken from an old wharf after 25 years' service; A is Ironbark, B and C Turpentine. Nos. 11 are portions of timber from a Northern River, and show large diameter of *Cobra* holes compared with local experience.

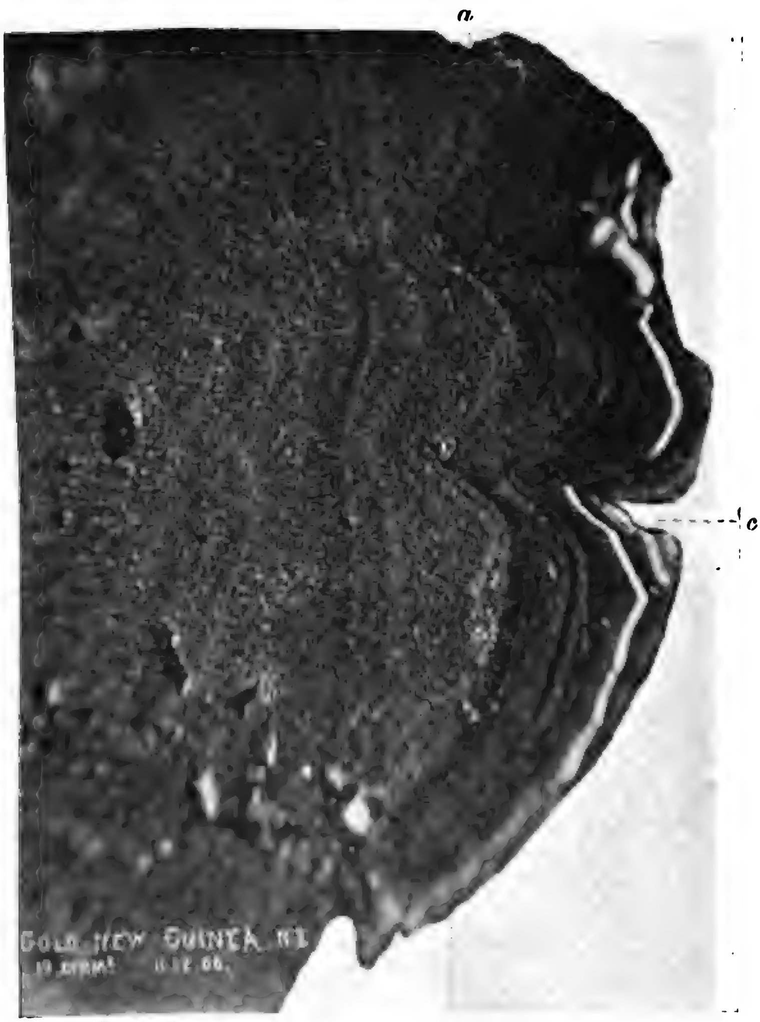
Longitudinal Sections of two Piles showing ravages of *Limnoria* and *Sphaeroma*. The right hand side of No. 6 is the work of the *Limnoria*; the remainder *Sphaeroma*. There are very few *Cobra* holes.



End grain of an Oregon log showing characteristic work of the *Limnoria*.



End grain of an Oregon log showing characteristic work of the *Limnoria.*



GOLD NUGGET, NEW GUINEA Enlarged 19 diameters.

Fine-grained banded Rhyolite Tuffs showing miniature faulting, from Oaky Creek.

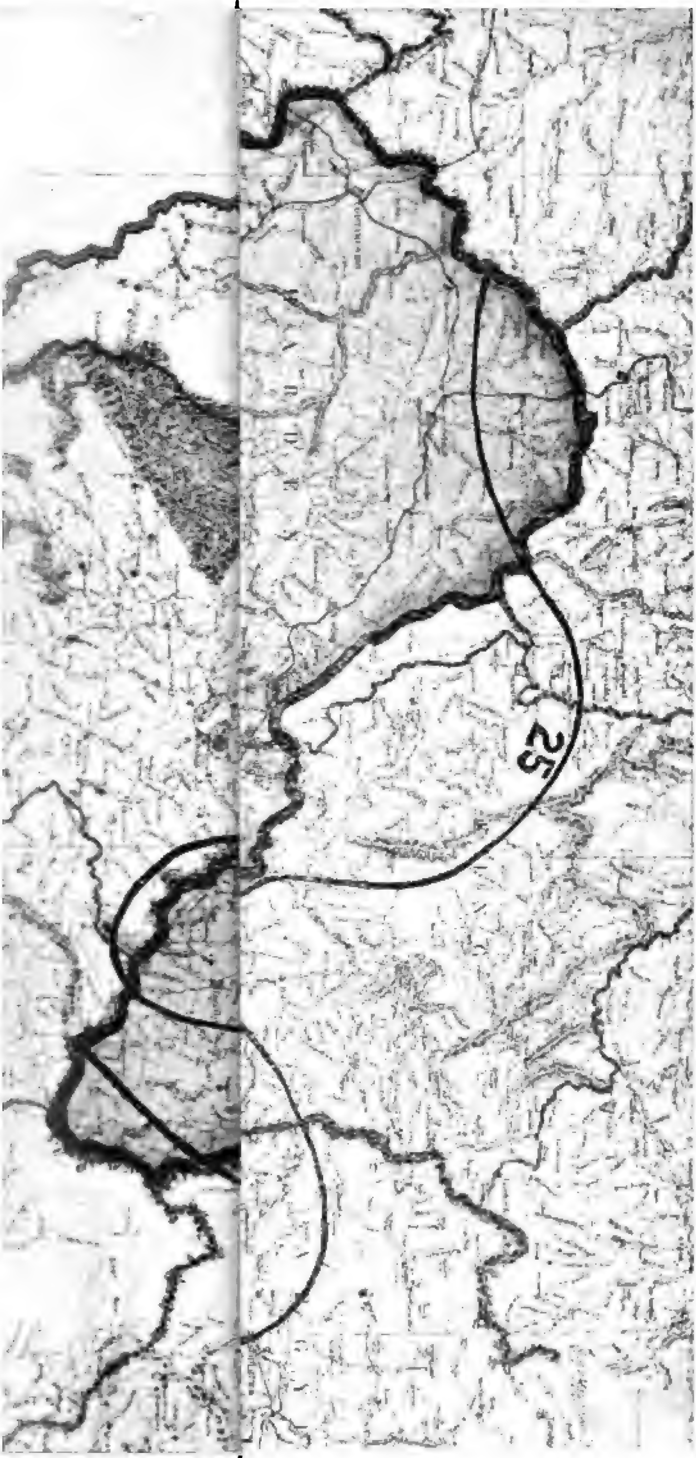
(Natural Size.)

Journal Royal Society of N.S.W., Vol. XL., 1906. *Plate XIV.*

Lingula Beds (Devonian), Gap Creek.

pecimen of interbedded Cherts and Tuffs (Intrusive Tuffs ?) from Gap Creek. The darker portions are the Chert bands.

(Half Natural Size.)



Appe[redacted]

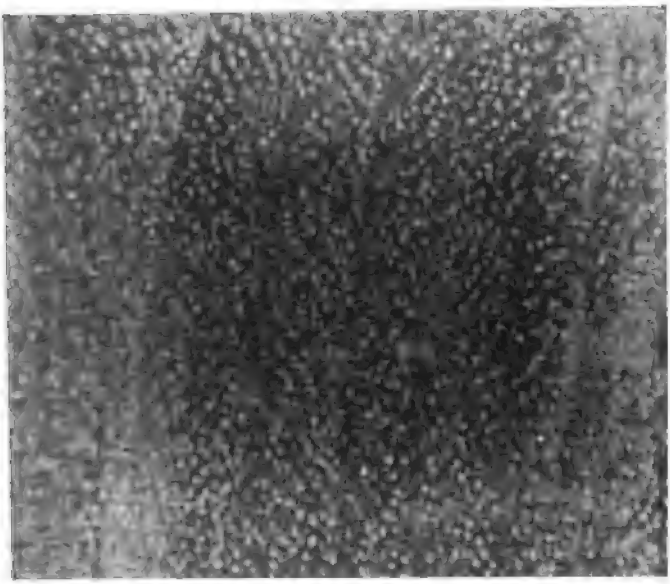


Fig. 1—Red Ironbark, *E. sideroxylon* × 6.

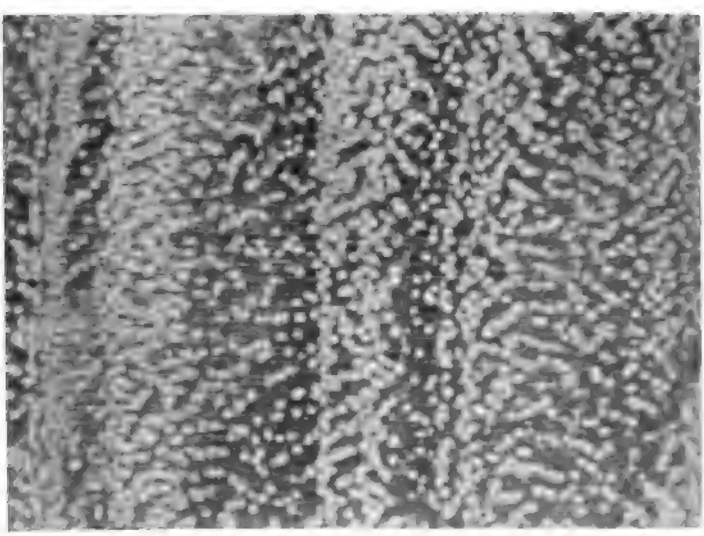


Fig. 2—Bastard Box, *E. polyanthema.* × 6.

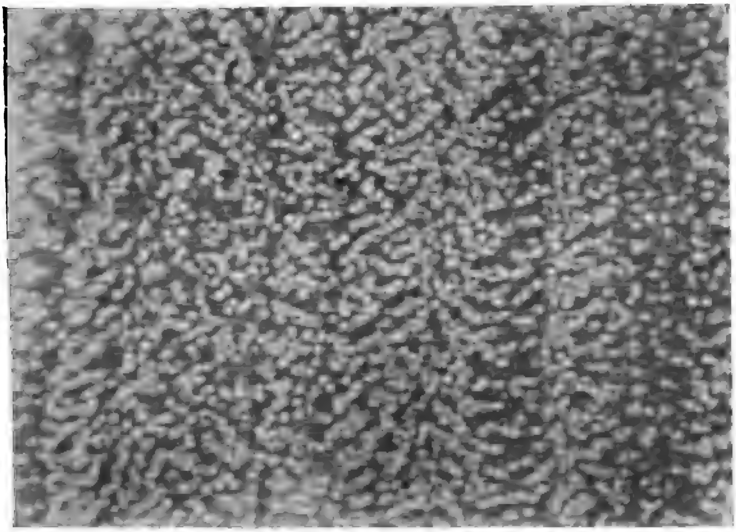


Fig. 3—Box, *E. hemiphloia*.

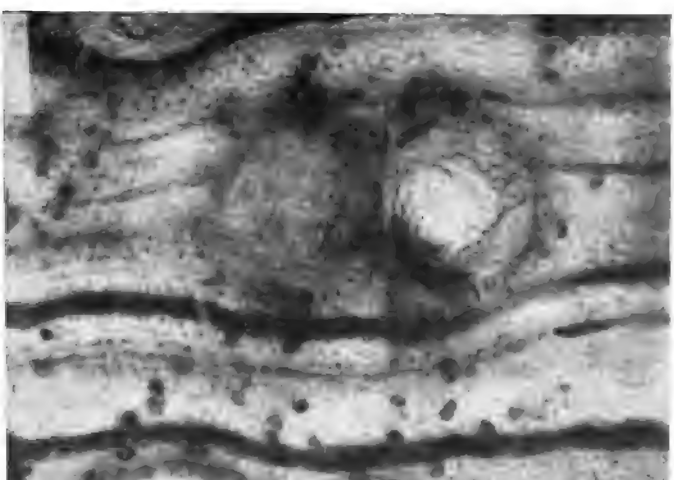


Fig. 4—Narrow-leaved Ironbark, *E. crebra*, × 180.

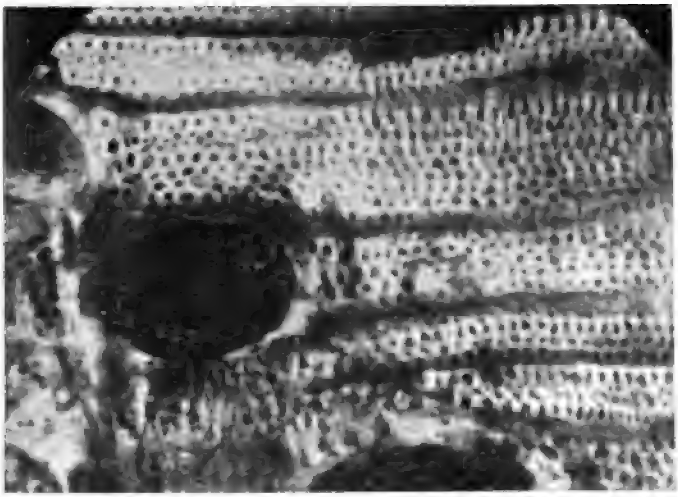


Fig. 5—Red Slaty Gum, *E bicolor.* × 180.

Fig. 6—Box, *E. hemiphloia.* × 180.

ABSTRACT OF PROCEEDINGS

Payments.	£ s. d.	£ s. d.
Attendances at Meetings	9 15 0	
Assistant Secretary	250 0 0	
Books and Periodicals	80 16 2	
Bookbinding	12 11 6	
Collector	7 6 7	
Freight, Charges, Packing, &c....	3 15 3	
Furniture and Effects	1 0 0	
Gas	13 18 8	
Insurance	9 7 8	
Interest on Mortgage (5 quarters)	70 0 0	
Petty Cash Expenses	8 11 9	
Postage and Duty Stamps	25 10 0	
Printing	23 6 0	
Printing and Publishing Journal	255 4 2	
Printing Extra Copies of Papers	6 9 6	
Rates	81 13 6	
Repairs	5 3 1	
Stationery	8 15 3	
Sundries	17 4 5	
Total Payments		890 8 6
Building and Investment Fund, Composition for Life Membership	21 0 0	
Advance from General Account 31/3/97 repaid	8 0 6	
		29 0 6
Clarke Memorial Fund—Loan repaid	100 0 0	
Interest to date	0 13 4	
		100 13 4
Bank Charges		0 16 7
Balance on 31st March, 1906, viz.:—		
Cash in Union Bank...	22 5 7	
Cash in hand...	10 0 0	
		32 5 7
		£1053 4 6

BUILDING AND INVESTMENT FUND.

Dr.	£ s. d.	£ s. d.
Loan on Mortgage at 4%		1400 0 0
Composition for Life Membership, 1905 ...	21 0 0	
General Account advance 31/3/97 repaid ...	8 0 6	
Deposit in Govt. Savings Bank 31st March '05	32 1 0	
Interest	0 19 4	
		62 0 10
		£1462 0 10

Cr.		£ s. d.
Deposit in Government Savings Bank, March 31st, 1906	53 15 0	
Repairs to Building	8 5 10	
		62 0 10
Balance 31st March, 1906		1400 0 0
		£1462 0 10

CLARKE MEMORIAL FUND.

Dr.	£ s. d.
Amount of Fund, 31st March, 1905	485 14 2
Interest to 31st March, 1906	16 10 10
	£502 5 0

Cr.	£ s. d.
Deposit in Savings Bank of New South Wales, March 31, 1906	250 13 11
Deposit in Government Savings Bank, March 31, 1906 ...	251 11 1
	£502 5 0

AUDITED AND FOUND CORRECT, AS CONTAINED IN THE BOOKS OF ACCOUNTS.

DAVID FELL, C.A.A.
F. BENDER............ } *Honorary Auditors.*

SYDNEY, 24th April, 1906.

D. CARMENT, F.I.A., F.F.A. *Honorary Treasurer.*
W. H. WEBB *Assistant Secretary.*

A vote of thanks was passed to the Hon. Auditors, viz., Mr. DAVID FELL, C.A.A., and Mr. F. BENDER, for their services.

Dr. GREIG SMITH and Mr. L. HARGRAVE were appointed Scrutineers, and Mr. W. M. HAMLET deputed to preside at the Ballot Box.

There being no other nominations the following gentlemen were declared duly elected Officers and Members of Council for the current year :—

President:

Prof. T. P. ANDERSON STUART, M.D., LL.D.

Vice-Presidents:

Prof. WARREN, M. Inst. C.E., Wh.Sc.	F. H. QUAIFE, M.A., M.D.
H. C. RUSSELL, B.A., C.M.G., F.R.S.	H. A. LENEHAN, F.R.A.S.

Hon. Treasurer:

D. CARMENT, F.I.A., F.F.A.

Hon. Secretaries:

J. H. MAIDEN, F.L.S.	G. H. KNIBBS, F.R.A.S.

Members of Council:

S. H. BARRACLOUGH, B.E., M.M.E.	Prof. LIVERSIDGE, LL.D., F.R.S.
F. B. GUTHRIE, F.I.C., F.C.S.	R. GREIG SMITH, D.Sc.
G. H. HALLIGAN, F.G.S.	WALTER SPENCER, M.D.
W. M. HAMLET, F.I.C., F.C.S.	J. STUART THOM
T. H. HOUGHTON, M. Inst. C.E.	H. D. WALSH, B.E., M. Inst. C.E.

The certificates of five candidates were read for the third time, of one for the second time, and of six for the first time.

The following gentlemen were duly elected ordinary members of the Society. viz.:—

BASNET, NATHANIEL JAMES, Accountant, 'Loorose,' Punch-street, Mosman.

HENNING, EDMUND TREGENNA, B.E. Syd., Hunter's Hill.

RICHARDSON, H. G. V., Draftsman, Newcastle-street, Rose Bay.

SMALL, FREDERICK HENRY, M. Inst. C.E., Public Works Department.

WADE, JAMES SCARGILL, Assoc. M. Inst. C.E., Public Works Department.

Twenty-five volumes, 157 parts, 23 reports, 7 pamphlets, and 2 maps, total 214, being portion of the donations received since the last meeting, were laid upon the table and acknowledged, (including an Etymological Dictionary of the Scottish Language by John Jamieson D.D., in 5 vols., presented by Mr. W. A. Dixon, F.I.C., F.C.S.)

The Chairman made the following announcements:—

(1.) The Annual Dinner of the Society would be held on the 7th instant.

(2.) The series of Popular Science Lectures for the present Session would be delivered as follows:—

A series of Popular Science Lectures, illustrated by lantern slides, will be delivered at the Society's House, at 8 p.m., as follows :—

June 21—"*Some Results of Archæological Work in Jerusalem,*" by Professor ANDERSON STUART, M.D., LL.D.

July 19—"*Our Water Supply from source to distribution,*" by J. M. SMAIL, M. Inst. C.E., Engineer-in-Chief, Board of Water Supply and Sewerage, and E. S. STOKES, M.B., D.P.H., Medical Officer, Board of Water Supply and Sewerage.

Aug. 16—"*Sir Joseph Banks, the 'Father of Australia',*" by J. H. MAIDEN, F.L.S., Director of the Botanic Gardens.

Sept. 20—"*Recent Developments in Long Distance Electrical Transmission,*" by T. ROOKE, Assoc. M. Inst. C.E., City Electrical Engineer.

Nov. 15—"*Chapters in Early Australian History,*" by F. M. BLADEN, F.R.G.S., F.R.H.S. (Lond.).

(3.) A series of three Clarke Memorial Lectures would be delivered by Prof. E. W. SKEATS, D.Sc., F.G.S., Melbourne University, on the following dates:—

Monday, October 22—"*The Volcanoes of Victoria,*"

Thursday, October 25—"*The Origin of Dolomite,*"—(a. Early research and views as to its formation. β. Experimental work up to the year 1897).

Tuesday, October 30—"*The Origin of Dolomite,*"—(a. Recent experimental work including the chemical and mineralogical results of the examination of the Funafuti boring and of specimens from raised coral islands. β. The bearing of these investigations on the origin of dolomite. γ. Application of modern views to the dolomites of Tyrol and other areas.)

(4.) The Society's Journal and Proceedings, Vol. XXXIX., 1905, is in the binder's hands and would be forwarded to members without delay.

(5.) A lecture on "The Scenery of Mount Kosciusko," by His Honor Judge DOCKER, M.A., (illustrated by lantern slides) would be delivered May 14th, 1906.

The following letters were received and read :—

Berlin N., den 16 Januar 1906.

Hochgeehrter Herr—Sie hatten die Güte mir mitzuteilen, dass die Royal Society of New South Wales mich am 6 Dezember v. Js. zum Ehrenmitgliede ernannt hat. Ich habe mich über diese Ehrung umsomehr gefreut, als sie die erste Anerkennung meiner wissenschaftlichen Bestrebungen ist, die mir von Ihrem fernen Kontinent zuteil wird, und ich sehe darin den besten Beweis, wie sehr die Wissenschaft Gemeingut aller Kulturvölker ist.

Ich bitte Sie, hochgeehrter Herr, der Gesellschaft meinen verbindlichsten Dank für die Wahl übermitteln zu wollen und bin, mit dem Ausdruck meiner grössten Wertschätzung.

Ihr ergebener,
EMIL FISCHER

To the Hon. Secretary of the Royal Society of New South Wales,
Mr. G. H. Knibbs.

Istituto Chimico della R. Università di Roma,
Roma, li 5 Febbrojo, 1906.
Via Panisperna 89 B.

Hon. Secretary of the Royal Society, N.S.W.

Dear Sir,—I have received with the greatest pleasure your communication of the 8th December, and beg you to thank most heartily the President and all the members of your Society for the honour they gave me. With my best compliments I remain, Dear Sir, yours sincerely,

Professore STANISLAO CANNIZZARO,
Senatore del Regno d' Italia.

Kew, 14th January, 1906.

To the Hon. Secretary, Royal Society N.S. Wales.

Dear Sir,—I have to return my cordial thanks to the Royal Society for the distinguished honour conferred upon me in electing me to their Honorary Fellowship. I am only too conscious how sadly I am undeserving of the distinction. It is now a good many years since I retired from active botanical work.

Believe me, very respectfully and faithfully yours,
DANL. OLIVER.

---

269 Armagh-street, Christchurch, N.Z.,
December 17th, 1905.

Gentlemen,—Will you kindly convey to the members of the Royal Society of N.S. Wales the sincere thanks of myself and my family for their expression of deep sympathy with us in our sorrow.

I am yours faithfully,
ANNIE G. HUTTON.

To the Hon. Secretaries, Royal Society of N. S. Wales.

The motion of Professor LIVERSIDGE, that Rule XXVIII. be altered to read as follows, was carried unanimously:—"Meetings of the Council of Management **MAY** take place on the last Wednesday in every month **OR** on such other days as the Council may determine."

Mr. H. A. LENEHAN, F.R.A.S., then read his address.

A vote of thanks was passed to the retiring President, and Prof. T. P. ANDERSON STUART, M.D., LL.D., was installed as President for the ensuing year.

Prof. STUART thanked the members for the honour conferred upon him.

EXHIBIT.

The Government Geologist, Mr. E. F. PITTMAN exhibited a specimen of diamond in the matrix. The specimen was found by Messrs. Pike and O'Donnell, in their claim at Oakey Creek, near Inverell. The diamond is a small one, weighing about one-third carat, and the material in which it is embedded is an igneous rock known as dolerite. The dolerite occurs at Oakey Creek as a pipe or dyke, and the specimen is of special interest as throwing some light upon the question of the origin of the diamond; for it is a fair assumption that the gem was actually formed in the dolerite when the latter was cooling or solidifying from the molten state. The origin of diamonds has for many years been a subject of controversy amongst scientific men. As is well known, the world's supply of diamonds is obtained chiefly from South Africa. The stones were at first found there in alluvial deposits formed of river gravels, but were ultimately traced back to a bluish-green rock, which proved to be a volcanic agglomerate filling the pipes of old volcanoes. The diamonds were found scattered irregularly through this agglomerate locally known as "blue-ground," and for some time it was thought that this was the actual matrix of the diamond. Fragments of a crystalline rock, known as eclogite, are however, found in the agglomerate, and ultimately Professor BONNEY, who has done a great deal of work in investigating the origin of diamonds, announced that in his opinion the eclogite was the actual matrix of the diamond, but that the eclogite occurred in the volcanic pipes in the form of water-worn pebbles, which had probably been derived from a bed of conglomerate

of still greater age, and which had been broken through by the volcano at the time of its eruption. Dolerite, however, as a matrix for the diamond, was quite unknown in any part of the world until the discovery of the specimen alluded to was made by Messrs. Pike and O'Donnell, near Inverell. There are several other known deposits of similar rock in the neighbourhood, and it seems more than probable that all the diamonds which have been won in Cope's Creek and the surrounding district have been derived from that source.

British Museum (Natural History),
Cromwell Road, London, S.W.

BLOOD-SUCKING INSECTS AND TROPICAL DISEASES.

The importance of blood-sucking insects and other animals as possible disseminators of pathogenic organisms being now universally recognised, it is absolutely essential, firstly that medical men and others engaged in improving the sanitation of tropical countries should have the means of determining correctly the names of blood-sucking species with which they may come into contact; and secondly that a well-preserved collection of modern specimens should be available in London for comparison.

The British Museum has already dealt with the Mosquitoes and Tsetse-flies, and it is now proposed to publish on similar lines a further series of monographs on the other blood-sucking forms. The material at present at our disposal, however, is insufficient for this purpose, and it is therefore hoped that all medical men and naturalists residing in British Colonies, or in the tropics in any part of the world, will make special endeavours to obtain specimens and send them addressed to the Director, British Museum (Natural History), Cromwell Road, London, S.W., together with notes on the names, habits, and distribution of the insects.

The accompanying pamphlet (to be seen in the Library of the Royal Society of N. S. Wales), which has been prepared in order to assist those who may be willing to help the Museum in this way, is mainly devoted to the blood-sucking Flies (Diptera), and

contains a résumé of what is known of their appearance, habits and life history, with illustrations of typical forms, and full directions as to the collection and transmission of specimens to England. When a collection is despatched, a separate letter of advice stating the fact should always be sent; the expense of sending collections to the Museum, by parcel post or otherwise, will be refunded.

E. RAY LANKESTER, Director.

December 10, 1904.

ABSTRACT OF PROCEEDINGS, JUNE 6, 1906.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, June 6th, 1906.

Prof. T. P. ANDERSON STUART, M.D., LL.D., President, in the Chair.

Thirty members and three visitors were present.

The minutes of the preceding meeting were read and confirmed.

Two new members enrolled their names and were introduced.

His Honor Judge DOCKER and Dr. R. GREIG SMITH were appointed Scrutineers, and Mr. D. CARMENT deputed to preside at the Ballot Box.

The certificate of one candidate was read for the third time, of six for the second time, and of one for the first time.

The following gentleman was duly elected an ordinary member of the Society:—

LEE, ALFRED, 'Glen Roona,' Bondi.

The Chairman made the following announcements:—

1. That the Monthly Meeting of the Engineering Section would be held on Wednesday, June 20, at 8 p.m.

2. That the first Popular Science Lecture of the Session would be delivered on Thursday, June 21, at 8 p.m., on "Some results of Archæological work in Jerusalem," by Professor T. P. ANDERSON STUART, M.D., LL.D.

3. That several members of the late Economic Section desired the resuscitation of the Section. He referred to the practical importance of the subject, and hoped the matter would meet with the hearty co-operation and support of the members individually.

4. That the Council thought it would be a fitting tribute to the memory of the late Mr. CHARLES MOORE (who had for so many years been closely connected with the Royal Society and was indeed, at the time of his death, the "Father of the Society,") to have his portrait hung in the Society's house. The Council invited subscriptions for this purpose, the amount to be limited to 5/- each, and he trusted the members would kindly help in the matter, however small the contribution.

The Engineering Section reported the election of its officers and Committee for the current Session, as per printed cards which had already been distributed.

Eleven volumes, 162 parts, 4 reports, 9 pamphlets, and one map, total 187, received as donations since the last meeting, were laid upon the table and acknowledged.

Mr. F. B. GUTHRIE, F.I.C., F.C.S., delivered a lecturette, (illustrated by lantern slides) on "The Plant's supply of Nitrogen," of which the following is an abstract:—Importance of nitrogen to plant growth. Different ways by which the plant obtains its nitrogen. Nitrification; explanation of increased fertility brought about by top-dressing sterile soils with comparatively small quantities of fertile ones. Work of Pasteur, Schloessing and Müntz, Warington, Frankland, and Winogradsky. Different classes of organisms are involved in the nitrification of animal or vegetable refuse,

putrefactive moulds and bacteria converting it first into humus with evolution of carbonic acid and metabolism of the nitrogenous matter into simpler forms, such as amides and ammonium carbonate. The further nitrification of the ammonium salts is the work of other specialized organisms, some of which convert the ammonium compounds into nitrites and others complete the oxidation to nitrates. Conditions favourable to nitrification are (1) presence of suitable food for the development of the organisms, namely lime, potash, sulphates and phosphates and free carbonic acid. (2) Suitable temperature, the optimum being about 36° C. (3.) Presence of a base, such as carbonate of lime, to combine with the free nitrous and nitric acid produced. (4.) Presence of a suitable amount of moisture. (5) Absence of too strong light. (6.) Presence of a sufficiency of oxygen, the process being essentially an oxidising one.

All the nitrogen is ultimately derived from the atmosphere, which is converted into organic material in several ways. Free-living nitrogen-fixing organisms which are present in all soils have the power of fixing atmospheric nitrogen and thereby enriching the soil in nitrogenous organic material. These thrive best in soils rich in organic matter but poor in nitrogen, the fixation being due to the oxidation of carbohydrates which supplies the energy. In the decayed leaves of forest trees these organisms are very abundant, the fallen foliage of beech-trees having been found to accumulate 19 lbs. nitrogen per acre.

In the case of leguminous plants, nitrogen-fixing bacteria are found in nodules formed on the roots, which bacteria are either parasitic or symbiotic with the host plant. This explains the enormous gain in nitrogen resulting from the growth of such crops as cow-peas, even when the crop is not ploughed under. Attempts have been made to prepare pure cultures of these root organisms by different means for

use in directly inoculating soil or seed. Preparations of Nobbe, Hiltner, Moore. None of these can claim anything like certainty in their action and they have not so far advanced beyond the experimental stage nor established themselves as part of ordinary farm practice.

The problem of artificially fixing atmospheric nitrogen economically in a form suitable for the nutrition of plants was next discussed. Calcium cyanamide, prepared by passing nitrogen over calcium carbide at a white heat, has been found to possess manurial value, due to the formation of ammonia in contact with moisture. Experiments so far indicate that there is nothing to show that it has a higher manurial value than ammonium sulphate with which it cannot at present compete in price. There are also certain disadvantages in its use, depending on the difficulty of mixing with other manures, the risk of injuring germination etc. More promising methods appear to be in the direct union of the oxygen and nitrogen in the air by means of the electric arc. Among processes which have been tried on the commercial scale with some success are Bradley and Lovejoy's, which was in operation at Niagara till 1904. The most successful process up to the present is that of Birkeland and Eyde which is now being carried out on an enormous scale in Norway. In this process air is sparked in a specially constructed electric furnace by means of an arc spread out into a fan by means of electromagnets. The air thus sparked is passed through towers charged with milk of lime, and the nitrite formed converted into calcium nitrate by treatment with nitric acid. The product is put on the market either in this form or is converted into a non-hygroscopic basic nitrate by calcining it with lime (Messel's process). Calcium nitrate appears to be just as effective as a manure as sodium nitrate and the question of the future of the industry becomes one of cheapening the unit cost of the current.

Remarks were made by Dr. Quaife and the President.

EXHIBITS:

Mr. J. H. Maiden exhibited some plants (herbarium specimens) which, in drying, stain paper, and made some explanatory notes in drawing attention to the phenomena. Remarks were made and questions asked by Mr. R. Helms, Mr. W. J. Clunies Ross, and the President. Mr. Maiden replied.

+Mr. C. A. Sussmilch exhibited a fossil insect-wing from the Upper Coal Measures at Newcastle, collected by Mr. C. Newling. The specimen will be described at a later meeting.

ABSTRACT OF PROCEEDINGS, JULY 4, 1906.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, July 4th, 1906.

Prof. T. P. Anderson Stuart, M.D., LL.D., President, in the Chair.

Thirty-three members and one visitor were present.

The minutes of the preceding meeting were read and confirmed.

An apology for non-attendance through illness was received from Dr. Walter Spencer.

Mr. R. H. Mathews and Mr. Lawrence Hargrave were appointed Scrutineers, and Dr. R. Greig Smith deputed to preside at the Ballot Box.

The certificates of six candidates were read for the third time, of one for the second time, and of five for the first time.

The following gentlemen were duly elected ordinary members of the Society:—

HODGSON, RALPH VIVIAN, Barrister-at-Law, Wentworth Court, Elizabeth-street; p.r. 'Tower Cottage,' Old South Head Road.

KEENAN, Rev. BERNARD, D.D., etc., 'Royston,' Rose Bay.

McINTOSH, ARTHUR MARSHALL, Dentist, 'Calahla,' Manly.

OSCHATZ, ALFRED LEOPOLD, Teacher of Languages, 167 Victoria-street, Potts Point.

PAWLEY, CHARLES LEWIS, Dentist, 137 Regent-st., City.

WOOLNOUGH, WALTER GEORGE, D. Sc., etc., Demonstrator in Geology, University of Sydney.

The Chairman made the following announcements:—

1. That the Monthly Meeting of the Engineering Section would be held on Wednesday, July 18th, at 8 p.m.

2. That the Second Popular Science Lecture of the Session would be delivered on Thursday, July 19th, at 8 p.m., on 'Our Water Supply from source to distribution,' by J. M. SMAIL, M. Inst. C.E., Engineer-in-Chief, Board of Water Supply and Sewerage, and E. STOKES, M.B., D.P.H., Medical Officer, Board of Water Supply and Sewerage.

A circular was read from the Farrer Memorial Committee inviting contributions towards establishing a suitable memorial to perpetuate the memory of the late Mr. W. J. FARRER, who has done so much important work in the improvement of wheats. Subscriptions are received by Mr. F. W. A. DOWNES, M.L.A., and Mr. G. W. WALKER.

Twenty-seven volumes, 60 parts, and 15 reports, total 102, received from the United States of America as donations, were laid upon the table and acknowledged.

THE FOLLOWING PAPER WAS READ:

"The testing of building materials on abrasion by the sand blast apparatus," by H. BURCHARTZ, of the Royal Testing Laboratory, Berlin, (Communicated by Professor W. H. WARREN, M. Inst. C.E.

Remarks were made by Mr. W. A. DIXON, Dr. SCHEIDEL and the President.

Mr. W. M. HAMLET, F.I.C., F.C.S., delivered a lecturette illustrated by lantern slides, when the new electric projection lantern kindly provided by Dr. QUAIFE was used with excellent results. Mr. HAMLET took for his subject "The measurement of human energy," which he defined as the sum of the activities of a comparatively few chemical elements, such as nitrogen, carbon, hydrogen, phosphorus, calcium, sodium, and iron; these with a few others entered into a host of permutations that ran the whole gamut of the melody of life. Attempts had from time to time been made to estimate the energy of which the human body was capable, and to present its equivalent value in foot-pounds and kilogram-meters the method being essentially a thermodynamic one. Success had followed the attempt, and advances had been made in the study of mental and physical energy. To come to any true conception as to its value, we must, as Lord Kelvin had pointed out, make careful weighings and measurements; indeed, we know little or nothing about a phenomenon until we were able to measure it. Between the estimation of any coefficient representing mental energy, and the more accessible measurement of physical energy, a barrier exists, which prevents us from even approximating the dynamic values of the intra-cellular energy of the nervous system. The work done in walking a given distance on a level road afforded an easy means of estimating work done, and the lecturer gave examples in his own case of energy amounting to between four and five hundred foot-tons per day. Compared with a sedentary life demanding but 1,200 calories per diem, the former required two and a half times the food intake, namely, a fuel value of 3,000 K. The nitrogen metabolism was taken into account and it was found that the old standard of 100 grams of proteid was excessive, and that better work and less fatigue, was felt when the intake of food was regulated in the way suggested by Chittenden. A description was

given of Professor Atwater's respiration chamber and t[illegible] ergometer, by which definite values based on therm[illegible]-dynamic principles were obtained in cases of student[illegible] athletes and others who had volunteered to offer themselves as living experiments. The lecturer stated that he had found from his own observations and experiments, that a much smaller intake of food sufficed for mental work, much smaller than that given by Pettenkofer and Voit, and more nearly that found by Chittenden.

Remarks were made by Messrs. J. H. MAIDEN, J. U. C. COLYER, S. H. BARRACLOUGH, W. A. DIXON, and the President. Mr. HAMLET replied.

On the suggestion of Mr. MAIDEN, it was agreed that at some future meeting, to be arranged by the Council, a discussion be held on the subject of 'The nutrition of man.' Members desiring to take part in the 'symposium' were invited to send in their names to the Honorary Secretaries. At the request of the President, Mr. MAIDEN will begin the discussion.

It is proposed to issue the Society's Volume in Parts, unbound, to such members as desire the publication to be issued to them in that form. The precise number of parts to be issued each year has not yet been decided upon; they may be issued irregularly. A printed form of application is obtainable for the convenience of members. To those members who do *not* sign the form, the bound volume will be delivered at the end of each session as heretofore.

EXHIBITS:

Mr. HAMLET exhibited a Colorimeter by Dubosq of Paris, which he had found useful in estimating the intensity of colours in artificially coloured food stuffs. Another form of Colorimeter by Stammer, was exhibited, having a more extended scale, and adapted for measuring the colour in fictitious raspberry syrups, fruit essences, etc.

Mr. MAIDEN exhibited some dates grown at the Lake Harry Date Palm Plantation, near Hergott, about 500 miles north of Adelaide, by Mr. Walter Gill, Conservator of Forests, of South Australia, which, it will be observed, are of pleasant flavour. They are the product of the "Deglet Nour" variety sent by the French Government from Algeria to South Australia on September 11th, 1894. There are 45 palms in full bearing, and the fruit is sold retail in Adelaide at 8d. per pound. The question suggests itself, why is New South Wales backward in this matter? We already have this variety at the Pera Bore.

Dr. F. H. QUAIFE exhibited a few slides to show the sharp definition obtainable by his lantern with the electric light recently installed.

The best thanks of the meeting were conveyed to Dr. QUAIFE for his kindness in lending the lantern to the Society until it acquires one of its own.

ABSTRACT OF PROCEEDINGS, AUGUST 1, 1906.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, August 1st, 1906.

Prof. T. P. ANDERSON STUART, M.D., LL.D., President, in the Chair.

Thirty members were present.

The minutes of the preceding meeting were read and confirmed.

Five new members enrolled their names and were introduced.

Mr. C. A. SUSSMILCH and Mr. A. J. WALKOM were appointed Scrutineers, and Mr. D. CARMENT deputed to preside at the Ballot Box.

The certificate of one candidate was read for the third time, of five for the second time, and of six for the first time.

The following gentleman was duly elected an ordinary member of the Society:—

LONEY, CHARLES AUGUSTUS LUXTON, Engineer, Equitable Buildings, George-street.

The Chairman made the following announcements:—

(1). That it was intended to form a Dental Section in connection with the Society.

(2.) That about £2 more was required for the portrait of the late Mr. CHARLES MOORE.

(3.) That subscriptions towards the Farrer Memorial would be thankfully received by the Hon. Secretaries.

(4.) That the third Popular Science Lecture of the Session would be delivered on Thursday, August 16th, at 8 p.m., on "Sir Joseph Banks, the 'Father of Australia,'" by J. H. MAIDEN, F.L.S., Government Botanist and Director of the Botanic Gardens.

(5.) That the Engineering Section would hold a Conversazione on Thursday, August 30, at 8 p.m., in lieu of the usual monthly meeting.

Twenty-four volumes, 517 parts, 19 reports, and 3 pamphlets, total 563, received as donations, were laid upon the table and acknowledged.

THE FOLLOWING PAPERS WERE READ:

1. "The Australian Melaleucas and their Essential Oils," Part I., by RICHARD T. BAKER, F.L.S., Curator, and HENRY G. SMITH, F.C.S., Assistant Curator, Technological Museum, Sydney.

2. "On *Vitis opaca*, F.v.M., and its Enlarged Rootstock," by RICHARD T. BAKER, F.L.S., Curator, and HENRY G. SMITH, F.C.S., Assistant Curator, Technological Museum, Sydney.

Remarks were made by Mr. J. H. MAIDEN, Dr. R. GREIG SMITH, Mr. J. A. SCHOFIELD, Mr. F. B. GUTHRIE, Dr. F. H. QUAIFE, and the Chairman. Mr. BAKER replied.

3. "Investigation of the Disease in Cattle known as 'Rickets,' or 'Wobbles,' and examination of the Poisonous Principle of the Zamia Palm (*Macrozamia Fraseri*)," by E. A. MANN, Government Analyst and Chemist to the Department of Agriculture, W.A., and T. I. WALLAS, Acting Physiologist and Pathologist to the Department. Preliminary notice. (Communicated by R. GREIG SMITH, D.SC., etc.)

"For some time we have been carrying on investigations on the above subject, as the result of which we have come to the conclusion that the effects upon cattle induced by eating the *Macrozamia Fraseri*, are caused by the presence in the plant of acid potassium oxalate ("Salts of Sorrel.") This is a confirmation of the results of an analysis made by a Mr. Norrie prior to 1876, and reported to the Royal Society of New South Wales by F. Milford, M.D. (Journal of the Soc., Vol. x., p. 295.) This analysis, which was made on another species (*Macrozamia spiralis*) appears to have been overlooked by chemists making subsequent examinations of the plant, and we have been unable to find any indication that the presence of oxalates was associated by other investigators with the observed effects. We hope to be able to submit a full report of our experiments, which are now approaching completion, at an early date."

Remarks were made by Mr. J. H. MAIDEN, Prof. LIVERSIDGE, Mr. F. B. GUTHRIE, and the President. Dr. GREIG SMITH replied.

EXHIBITS :

1. Lenticular basalt, by Professor LIVERSIDGE. At Emu Bay, Tasmania, there is a very fine outcrop of columnar basalt. The faces of many of the columns, where weathered and acted upon by the sea water, show an irregular lamellar structure, as if the column were made up of thin imperfect plates or layers, and the tops of some of them have an imbricated appearance, from being covered with small, more or less lenticular shaped, pieces of weathered basalt. This structure is probably a modification of the cup and cone joints common in basalts.

2. Specimens of pure Tin Metal from Mount Bischoff Mine in Tasmania. The molten metal had been dropped into water, resulting in beautiful fantastic incrustation like masses. By Professor ANDERSON STUART.

3. Mr. C. A. SUSSMILCH, exhibited two large geodes in basalt coated with large and beautiful crystals of quartz and calcite. In one example the quartz was brownish-black in colour (cairngorm), and in the other was of a pale amethyst-pink colour. In both examples the calcite crystals were of the type known as "Nail Head Spar," some of which are over an inch in diameter. The specimens were obtained from the old Dundas Quarry near Parramatta.

4. Mr. R. T. BAKER, F.L.S., exhibited (*a*) Section of a Eucalyptus tree 41 years old. This specimen was cut from *Eucalyptus dealbata*, about 12 feet from the ground, and measures 13½ inches in diameter, and was planted for timber by Mr. W. Shipton, at Verona. The annual rings are not well defined, and run into each other, so that it would be impossible to determine its age by them. (*b*) Rabbit bones found inside a ewe, which was in a perfectly healthy condition at the time of slaughtering. These bones were coated with an encrustation of calcium carbonate, phosphate, and oxalate. (c) A specimen of a radio-active

material (carnolite) from Olney, South Australia. (*d*) Specimens of a radio-active material, from Silverton, New South Wales, found by Mr. E. J. Blanch. Mr. BAKER also exhibited specimens in illustration of the papers by himself and Mr. SMITH.

ABSTRACT OF PROCEEDINGS, SEPTEMBER 5, 1906.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, September 5th, 1906.

H. A. LENEHAN, F.R.A.S., Vice-President, in the Chair.

Twenty-five members were present.

The minutes of the preceding meeting were read and confirmed.

Five new members enrolled their names and were introduced.

Mr. R. H. CAMBAGE and Mr. G. HOOPER were appointed Scrutineers, and Dr. WALTER SPENCER deputed to preside at the Ballot Box.

The certificates of five candidates were read for the third time, of six for the second time, and of three for the first time.

The following gentlemen were duly elected ordinary members of the Society:—

ADAMS, WALTER E., Assistant Engineer, Sydney Harbour Trust, Circular Quay.

GOSCHE, VESEY RICHARD, Consul for Nicaragua, 15 Grosvenor-street.

GOSCHE, W. A. HAMILTON, Electrical Engineer, 40 and 42 Clarence-street.

RITCHIE, ALEX. MACDONALD, Civil Engineer, 'Ercildoune,' Elizabeth Bay Road.

WHITEHEAD, LINDSAY, Acting Manager, Bank of New South Wales, Head Office, George-street.

The Chairman made the following announcements:—

1. That the fourth Popular Science Lecture of the Session would be delivered on Thursday, September 20th at 8 p.m. on "Recent developments in long distance electrical transmission," by T. ROOKE, Assoc. M. Inst. C.E., City Electrical Engineer.

2. That the Monthly Meeting of the Engineering Section would be held on Wednesday, September 19th, at 8 p.m.

THE FOLLOWING PAPERS WERE READ:

1. "Port Sydney," by LAWRENCE HARGRAVE.

Remarks were made by Mr. G. H. HALLIGAN, Mr. R. V. HODGSON, Dr. F. H. QUAIFE, and Mr. T. H. HOUGHTON.

2. "The International Rules of Botanical Nomenclature (adopted by the International Botanical Congress of Vienna, 1905)," by J. H. MAIDEN, Government Botanist and Director of the Botanic Gardens, Sydney.

Remarks were made by the Chairman and Mr. R. T. BAKER.

EXHIBIT.

A series of photographs showing progress of construction of the Cataract Dam, kindly lent by the Acting Under Secretary, Department of Public Works. Explanatory remarks were made by Mr. ALGERNON PEAKE.

ABSTRACT OF PROCEEDINGS, OCTOBER 3, 1906.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, October 3rd, 1906.

Prof. T. P. ANDERSON STUART, M.D., LL.D., President, in the Chair.

Thirty members and six visitors were present.

The minutes of the preceding meeting were read and confirmed.

Messrs. C. G. HODGSON and JAMES TAYLOR were appointed Scrutineers, and Dr. F. H. QUAIFE deputed to preside at the Ballot Box.

The certificates of six candidates were read for the third time, of three for the second time, and of three for the first time.

The following gentlemen were duly elected ordinary members of the Society:—

BINNIE, HERBERT, Merchant, 524 Kent-street.

MAITLAND, LOUIS DUNCAN, Dental Surgeon, 6 Lyons Terrace, Liverpool-street.

NESBITT, T. H., Town Clerk of Sydney, Town Hall.

NICHOLAS, HAROLD SPENCE, B.A. Oxon., LL.B., Barrister-at-Law, Chambers, Phillip-street.

TAYLOR, ALLEN, The Right Hon., Lord Mayor of Sydney, 'Ellerslie,' 85 Darlinghurst Road.

TAYLOR, HORACE, Registrar, Dental Board, 7 Richmond Terrace, Domain.

The President made the following announcements:—

1. That the portrait of the late Mr. CHARLES MOORE, which had been subscribed for by a number of members, was finished and had been placed in the large hall.

2. That a course of three Clarke Memorial Lectures would be delivered at the Royal Society's House, at 8 p.m., by Prof. E. W. SKEATS, D.Sc., F.G.S., Melbourne University, on the following dates:—

Monday, October 22—"*The Volcanoes of Victoria.*"

Thursday, October 25—"*The Origin of Dolomite.*"—(*a.* Early research and views as to its formation. *β.* Experimental work up to the year 1897).

Tuesday, October 30—"*The Origin of Dolomite.*"—(*a.* Recent experimental work including the chemical and mineralogical results of the examination of the Funafuti boring, and of specimens from raised coral islands. *β.* The bearing of these investigations on the origin of dolomite. *γ.* Application of modern views to the dolomites of Tyrol and other areas.

These lectures would be illustrated by lantern slides and by microscopic rock sections, shown in the Wright-Newton projecting microscope and micro-polariscope.

3. That the Monthly Meeeting of the Engineering Section would be held on Wednesday, October 17th, at 8 p.m.

Thirty-three volumes, 210 parts, 36 reports, and 30 pamphlets, total 309, received as donations, were laid upon the table and acknowledged.

A symposium on "The Nutrition of Man," was, at the request of the President, introduced by Mr. J. H. MAIDEN, and continued by the following speakers:—Dr. R. GREIG SMITH, MR. W. M. HAMLET, Dr. WALTER SPENCER, Mr. C. G. HODGSON, Mr. W. J. CLUNIES ROSS, Mr. JAMES TAYLOR, and the President.

The discussion was postponed to a subsequent meeting.

EXHIBITS:

Mr. OSCHATZ exhibited a number of New South Wales aboriginal implements of stone:—1. Conical stone taken from an aboriginal grave. 2. Part of a similar stone. 3. Piece of burnt clay used for cooking food. 4. Grinding stone (?). 5. Flint stone knife without handle. 6. Chipped

spear point with serrated edges. 7. Chipped spear point. 8. Quartz chip used for cutting. 9. Grinding stone (?). Nos. 1 – 5 from the Darling River; Nos. 6 – 9 from Middle Harbour, Port Jackson.

Mr. James Taylor, B. Sc., A.R.S.M., exhibited shell photographs, viz.:—Middle shell as finished. The other shells have each been fired *through* a special chrome nickel steel armour plate 1·78 calibres in thickness, without showing the slightest distortion. Made at Riga, Russia, by Messrs. Thos. Firth and Sons, Sheffield, England. Shells may be about 8 inches diameter, while the plate would be about 14 inches thick.

ABSTRACT OF PROCEEDINGS, NOVEMBER 7, 1906.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, November 7th, 1906.

Prof. T. P. Anderson Stuart, M.D., LL.D., President, in the Chair.

Twenty-seven members and one visitor were present.

The minutes of the preceding meeting were read and confirmed.

One new member enrolled his name and was introduced.

Dr. W. G. Woolnough and Mr. L. Hargrave were appointed Scrutineers, and Dr. F. H. Quaife deputed to preside at the Ballot Box.

The certificates of three candidates were read for the third time, of three for the second time, and of four for the first time.

The following gentlemen were duly elected ordinary members of the Society:—

BROWN, JAMES B., Resident Master, Technical School, Granville, 'Kingston,' Merrylands.

COLLEY, DAVID JOHN K., Superintendent, Royal Mint, Sydney.

EPPS, WILLIAM, Secretary, Royal Prince Alfred Hospital, Sydney.

The President made the following announcements:—

1. That the fifth Popular Science Lecture of the Session would be delivered on Thursday, November 15th at 8 p.m., on "Chapters in Early Australian History," by F. M. BLADEN, F.R.G.S., F.R.H.S. (Lond.)

2. That the monthly meeting of the Engineering Section would be held on Wednesday, November 21st, at 8 p.m.

3. That the Australasian Association for the Advancement of Science would open its next Session in Adelaide on January 7th, 1907.

Forty-nine volumes, 186 parts, 33 reports, and 17 pamphlets, total 285, received as donations were laid upon the table.

THE FOLLOWING PAPERS WERE READ:

1. "Notes on Some Native Tribes of Australia," by R. H. MATHEWS, L.S.

Some remarks were made by the President.

2. "Note on the Silurian and Devonian Rocks occurring to the west of the Canoblas Mountains, near Orange, N. S. Wales," by C. A. SÜSSMILCH, F.G.S.

Remarks were made by Prof. DAVID, Mr. W. J. CLUNIES ROSS, and Dr. WOOLNOUGH. The author replied.

Abstract of the fifth Popular Science Lecture, delivered 15 November, 1906, "Chapters in Early Australian History"

by F. M. BLADEN, F.R.G.S., F.R.H.S.:—Tracing the current of events in Europe during the latter half of the 18th century, the lecturer showed how the settlement of New South Wales was the outcome of the rivalry of the French and English nations. Referring to Captain Cook's landing place at Kurnell, Mr. Bladen expressed a hope that "some lasting monument would yet mark the rock where the great navigator first set foot on our coast, so that the spot might be known and reverenced as long as there is an Englishman in Australia. This would be a fitting addition to the splendid work done by Mr. Carruthers and his fellow trustees at Kurnell." The lecture was profusely illustrated by lantern slides, showing portraits of early Australian celebrities and views of old Sydney streets and buildings.

EXHIBITS.

1. By Mr. J. H. MAIDEN, piece of timber showing "A Natural Graft between Grey Gum (*Eucalyptus propinqua*) and Apple Tree (*Angophora subvelutina*), from Messrs. Allen Taylor & Co., Sydney, obtained from Cape Hawke, N. S. Wales."

2. By Mr. W. E. STOPFORD, an "Orrery."

ABSTRACT OF PROCEEDINGS, DECEMBER 5, 1906.

The General Monthly Meeting of the Society was held at the Society's House, No. 5 Elizabeth-street North, on Wednesday evening, December 5th, 1906.

Prof. T. P. ANDERSON STUART, M.D., LL.D., President, in the Chair.

Thirty-eight members and two visitors were present.

The minutes of the preceding meeting were read and confirmed.

Two new members enrolled their names and were introduced.

Mr. C. G. Hodgson and Mr. Joseph Brooks were appointed Scrutineers, and Dr. Walter Spencer deputed to preside at the Ballot Box.

The certificates of three candidates were read for the third time, of four for the second time, and of three for the first time.

The following gentlemen were duly elected ordinary members of the Society:—

Dixson, William, Tobacco Manufacturer, 45 Park-st.

Howle, Walter Creswell, Medical Practitioner, Pambula.

Redman, Frederick G., Chief Clerk, P. and O. Co's. Sydney Agency, 'Honda,' Shell Cove Road, Neutral Bay.

Sixty-six volumes, 935 parts, 35 reports, and 45 pamphlets, total 1081, received as donations, were laid upon the table.

Mr. F. Bender and Mr. W. Epps were appointed Honorary Auditors for the current year.

The following notices of motion for the next Annual Meeting were given in:—

1. By Prof. T. P. Anderson Stuart, M.D., LL.D., that Rule VIII. be altered to read as follows:—"The certificate shall be read at the *two* ordinary General Meetings of the Society, etc., instead of *three*."

2. By Mr. T. H. Houghton, that Library Rule V. be omitted.

3. By Mr. R. H. Mathews that Rule XXVI. be altered with the view to substituting March for May for the inaugural meeting of the Session.

The discussion on "The Nutrition of Man" was continued, the following gentlemen taking part:—Mr. L.

HARGRAVE, Prof. LIVERSIDGE, Mr. R. McMILLAN and Dr. CHAPMAN (by invitation of the President), Dr. F. H. QUAIFE and the President.

THE FOLLOWING PAPERS WERE READ:

1. "Bibliography of Australian, New Zealand, and South Sea Island Lichens," (second paper) by EDWIN CHEEL, [Communicated by J. H. MAIDEN, F.L.S.]

2. "Analysis of a specimen of Sea-water from Coogee," by C. J. WHITE, Caird Scholar, University of Sydney. (Communicated by Prof. LIVERSIDGE, F.R.S.)

3. "Analysis of the ash of a New South Wales Sea Weed, *(Ecklonia)*," by C. J. WHITE, Caird Scholar, University of Sydney. (Communicated by Prof. LIVERSIDGE, F.R.S.)

4. "Analysis of Roman Glass from Silchester, with special reference to the amount of manganese and iron present" by C. J. WHITE, Caird Scholar, University of Sydney. (Communicated by Prof. LIVERSIDGE, F.R.S.)

5. "Analyses of Chocolate Shale and of Tufaceous Sandstone, from the Narrabeen Series," by S. G. WALTON, Junior Demonstrator, University of Sydney. (Communicated by Prof. LIVERSIDGE, F.R.S.)

In these analyses special attention was paid to the determination of smaller pieces of the rarer elements.

6. "Gold nuggets from New Guinea, showing a Concentric Structure," by Professor LIVERSIDGE, F.R.S.

7. "The rate of decay of the excited radio activity from the atmosphere in Sydney," by S. G. LUSBY, B.A., and T. EWING, B.Sc., (Communicated by Prof. POLLOCK.)

Dr. HERMANN KLAATSCH of the Heidelberg University, kindly consented to give an account of his travels in Northern and North-western Australia, amongst the aboriginal population, on Thursday, December 13th, 1906.

The following donations were laid upon the table and acknowledged:—

TRANSACTIONS, JOURNALS, REPORTS, &c.

(The Names of the Donors are in *Italics*.)

AACHEN—Meteorologische Observatoriums. Deutsches Meteorologisches Jahrbuch für 1904, Jahrgang X. *The Director*

ACIREALE—R. Accademia di Scienze, Lettere ed Arti Degli Zelanti. Rendiconti e Memorie, Serie 3a, Vol. III., 1904-5, Memorie della Classe di Scienze; Vol. IV., 1904-5, Memorie della Classe di Lettere. *The Academy*

ADELAIDE—Department of Mines. A review of Mining Operations in the State of South Australia during the years 1905, 1906. Report on Geological Explorations in the West and North-west of South Australia by H. Y. L. Brown, also Contributions to the Palæontology of South Australia by R. Etheridge, Jr. 1905. Reports (Geological and General) resulting from the Explorations made by the Government Geologist and Staff during 1905. The Crown Lands Laws of South Australia, 1905. *The Department*

Observatory. Meteorological Observations during the years 1902-3, 1904. *The Observatory*

Royal Geographical Society of Australasia. Proceedings of the South Australian Branch, Sessions 1904-5 – 1905-6, Vol. VIII. *The Society*

Royal Society of South Australia. Memoirs, Vol. I., Part iii., 1905. Transactions and Proceedings, Vol. XXIX., 1905. ,,

AGRAM—Société Archéologique Croate. Vjesnik hrvatskoga Arheoloskoga Drustva, N.S. Svenska VIII., 1905. ,,

ALBANY—Advisory Board of Consulting Engineers. Report to the Governor upon its work relating to the Barge Canal from March 8, 1904 to Jany. 1, 1906. *The Board*

AMSTERDAM—Académie Royale des Sciences. Jaarboek, 1905, Proceedings of the Section of Sciences, Vol. VIII., Parts i., ii., 1905-6. Verhandelingen, (Eerste Sectie), Deel IX., Nos. 2, 3, 1905-6; (Tweede Sectie) Deel XII., Nos. 3, 4, 1906. Verslag van de Gewone Vergaderingen, Deel XIV., Gedeelte i., ii., 1905-6. *The Academy*

ANNAPOLIS, Md.—United States Naval Institute. Proceedings, Vol. XXXI., Nos. 3, 4, Whole Nos. 115, 116, 1905; Vol. XXXII., Nos. 1, 2, Whole Nos. 117, 118, 1906, *The Institute*

ANTWERP—Stad Antwerpen. Paedologisch Jaarboek, Jaargang Zesde, Afl. 1, [1906]. *The State*

AUCKLAND—Auckland Institute and Museum. Annual Report for 1905-6. *The Institute*

BALTIMORE—Johns Hopkins University. American Chemical Journal, Vol. XXXIII., Nos. 3 – 6; Vol. XXXIV., Nos. 1 – 6, 1905; Vol. XXXV., Nos. 1 - 4, 1906. American Journal of Mathematics, Vol. XXVII., No. 4, 1905, Vol. XXVIII., Nos. 1 - 3, 1906. American Journal of Philology, Vol.

BALTIMORE—*continued.*
xxv., No. 4, 1904; Vol. xxvi., Nos. 1–4, 1905. Maryland Geological Survey, Vol. v., 1905. The Financial History of Baltimore by J. H. Hollander, PH. D., 1899. University Circulars, Nos. 2–7, 9, 10, 1905; Nos. 1, 2, 1906. University Studies in Historical and Political Science, Series xxiii., Nos. 3–12, 1905; Series xxiv., Nos. 1, 2, 1906. *The University*

BANGALORE—Mysore Geological Department. Memoirs, Vol. iii., Part i. Records, Vol. v., 1903-4. *The Department*

BASEL—Naturforschende Gesellschaft. Verhandlungen, Band xviii., Heft 1, 2, 1905-6. *The Society*

BATAVIA—Government of Netherlands India. Description Géologique de l'Ile d' Ambon and Atlas par Dr. R. D. M. Verbeek, 1905. *The Government*

Royal Natural History Society of Netherlands India. Natuurkundig Tijdschrift voor Nederlandsch-Indië, Deel LXIV., 1905. *The Society*

BERGEN—Bergen Museum. Aarsberetning, 1905. Bergens Museums Aarbog, Hefte 2, 1904; Hefte 1–3, 1905; Hefte 1, 1906. An account of the Crustacea of Norway, Vol. v., Copepoda, Harpacticoida, Parts ix.–xiv., 1905-6. *The Museum*

BERKELEY—University of California. American Archaeology and Ethnology, Vol. iii. Botany, Vol. ii., Nos. 3–11. Bulletins, New Series. Vol. vi., No. 3; Vol. vii., No. 2. College of Agriculture, Agricultural Experiment Station Bulletin, Nos. 165–176; Circular No. 13. Department of Anthropology, pp. 1–38. Geology, Vol. iv., Nos. 2–13. Physiology, Vol. ii., Nos. 10–19; Vol. iii., Nos. 1–5. Preliminary Report of the State Earthquake Investigation Commission, 1906. Register, 1904-5. University Chronicle, Vol. vii., Nos. 2–4; Vol. viii., Nos. 1, 2, and Supplement. *The University*

BERLIN—Centralbureau der Internationalen Erdmessung. Veröffentlichung, No. 12, 1906. *The Bureau*

Gesellschaft für Erdkunde zu Berlin. Bibliotheca Geographica, Band xi., Jahrgang 1902. Zeitschrift, Nos. 6–10, 1905; Nos. 1–6, 1906. *The Society*

Königlich preussische Akademie der Wissenschaften. Sitzungsberichte, Nos. 39–53, 1905; Nos. 1–38, 1906. *The Academy*

Königlich preussische Geodätische Institutes. Veröffentlichung, N.F., Nos. 19–21, 23–25, 1905-6 *The Institute*

Königlich preussische Meteorologische Instituts. Bericht über die Tatigkeit im Jahre 1904, 1905. Deutsches Meteorologisches Jahrbuch für 1904, Heft i., ii. Die Niederschläge in den Norddeutschen Stromgebieten von Prof. Dr. G. Hellman, Erster Band, Text; Zweiter Band Tabellen i., Dritter Band, Tabellen ii., 1906. Ergebnisse der Beobachtungen an den Stationen ii. und iii., Ordnung im Jahre 1900, Heft iii. Ergebnisse der Magnetischen Beobachtungen in Potsdam im Jahre 1901-2. Ergebnisse der Niederschlags-Beobachtungen im Jahre 1902. ,,

BERNE—Département de l'Interieur de la Confédération Suisse, Section des Travaux Publics. Tableaux graphiques des Observations hydrométriques suisses et des températures de l'air et des hauteurs pluviales pour l' année 1904. Table de Récapitulation des Principaux Résultats des Observations hydrometriques suisses pour l'année 1902. *The Department*

Geographische Gesellschaft von Bern. Jahresbericht, Band XIX., 1903-4. *The Society*

BIRMINGHAM—Birmingham and Midland Institute Scientific Society. Records of Meteorological Observations taken at the Observatory, Edgbaston, 1905. „

BOLOGNA—R. Accademia delle Scienze dell' Istituto di Bologna. Memorie, Serie 6, Tome II., Fasc. 1–4, 1905. Rendiconto, Nuova Serie, Vol. IX., Fasc. 1–4, 1905. *The Academy*

BONN—Naturhistorischer Vereins der Preussischen Rheinlande, Westfalens und des Reg.-Bezirks Osnabrück. Verhandlungen, Jahrgang LXI., Hälfte 2, 1904; Jahrgang LXII., Hälfte 1, 1905. *The Society*

Niederrheinische Gesellschaft für Natur—und Heilkunde zu Bonn. Sitzungsberichte, Hälfte 2, 1904; Hälfte 1, 1905. „

BOSTON, Mass.—American Academy of Arts and Sciences. Proceedings, Vol. XL., No. 24, 1905; Vol. XLI., Nos. 8–34, 1905-6; Vol. XLII., Nos. 1 - 5, 1906. The Rumford Fund. *The Academy*

Boston Society of Natural History. Proceedings, Vol. XXXII., No. 6, 1905. *The Society*

BOULDER, Colo.—University of Colorado. Colorado College Publication, General Series No. 22. Science Series, Vol. XI., Nos. 42–46, 1905-6. Social Science Series, Vol. II., No. 5, 1905. Studies, Vol. III., Nos. 1 - 3, 1905-6. *The University*

BREMEN—Naturwissenschaftlicher Verein. Abhandlungen, Band XVIII., Heft 2, 1906. *The Society*

BRISBANE—Geological Survey of Queensland. Publications, No. 202.. Geological Sketch Map of Queensland showing mineral localities by B. Dunstan, F.G.S., 1905. *The Survey*

Queensland Acclimatisation Society. Annual Report, 1905, 1906. *The Society*

Department of Home Secretary. North Queensland Ethnography, Bulletin No. 8, 1905. *The Secretary*

Royal Society of Queensland. Proceedings, Vol. XIX., Part ii., 1906. *The Society*

BROOKLYN—Brooklyn Institute of Arts and Sciences. Cold Spring Harbor Monographs, VI., 1906. Science Bulletin, Vol. I., Nos. 7, 8, 1905-6. *The Institute*

BRUSSELS—Académie Royale des Sciences, des Lettres et des Beaux-Arts. Annuaire, 1906. Bulletin de la Classe des Sciences, Nos. 6–12, 1905; Nos. 1–4, 1906. *The Academy*

Association Internationale pour l'Etude des Regions Polaires par Henryk Arctowski, 1905. *The Association*

BRUSSELS—*continued.*

Société Royale de Botanique. Bulletin, Tome XLI., Fasc. 1 - 3, 1902-3; Tome XLII., Fasc. 1, 2, 1904-5. *The Society*

Société Royale Malacologique de Belgique. Annales, Tome XXXVI., 1901. „

BRUNSWICK—Vereins für Naturwissenschaft zu Braunschweig. Jahresbericht XIV,, 1903 - 5. „

BUENOS AIRES—Museo Nacional de Buenos Aires. Anales, Serie 3, Tome V., 1905. *The Museum*

CALCUTTA—Asiatic Society of Bengal. Journal, Vol. LXXIII., Part i, Extra No.; Part ii., Supplement; Part iii., Extra No., 1904. Proceedings, No. 11 Extra No., 1904. Journal and Proceedings, Vol. I., Nos. 1 - 10, and Extra No. 1905; Vol. II., Nos. 1 - 3, 1906. Memoirs, Vol. I., Nos. 1 - 9, 1905-6. *The Society*

Board of Scientific Advice for India. Annual Report for the year 1904-5. *The Board*

Department of Agriculture in India. Annual Report of the Imperial Department of Agriculture for the year 1904-5. Botanical Series, Vol. I., Nos, 1 - 4. Chemical Series, Vol. I., No. 1. Entomological Series, Vol. I., No. 1, 1905. *The Department*

Geological Survey of India. Records, Vol. XXXII., Parts iii., iv., 1905; Vol. XXXIII., Parts i. - iv.; Vol. XXXIV., Part i., 1906. *The Survey*

CAMBRIDGE—Cambridge Philosophical Society. Proceedings, Vol. XIII., Part iii. - v., 1905-6. Transactions, Vol. XX., Nos. 1 - 10, 1905-6. *The Society*

CAMBRIDGE (Mass.)—Museum of Comparative Zoölogy at Harvard College, Bulletin, Vol. XLIII., No. 4, 1906; Vol. XLVI., Nos. 10 - 14; Vol. XLVIII., Nos. 1 - 3, 1905-6; Vol. XLIX., [Geological Series, Vol. VIII.] Nos. 1 - 3, 1905-6; Vol. L., Nos. 1 - 3, 1906. Annual Report of the Curator, 1904-5. Memoirs, Vol. XXX., No. 2, 1905; Vol. XXXIII., 1906. *The Museum*

CAPE TOWN—Geological Commission. Geological Map of the Colony of the Cape of Good Hope, Sheet I., 1906. *The Commission*

Geodetic Survey of South Africa. Report of the Geodetic Survey of part of Southern Rhodesia, Vol. III., 1905. *The British South African Company*

South African Philosophical Society. Transactions, Vol. XVI., Parts ii., iii., 1905-6. *The Society*

CARLSRUHE—Grossherzoglich Technische Hochschule. Inaugural Dissertations (10). Programme, 1905-6. *The Director*

Naturwissenschaftliche Verein. Verhandlungen, Band XVIII., 1904-5. *The Society*

CASSEL—Vereins für Naturkunde. Abhandlungen und Bericht, XLIX., 1903 - 5. „

CHICAGO—Chicago Academy of Sciences. Bulletin, Vol. II., No. 4, 1902. Natural History Survey, Bulletin Ne. 3, Part ii.; No. 5, 1902. Special Publication, No. 1, 1902. *The Academy*

CHICAGO—*continued.*

Field Columbian Museum. Anthropological Series, Vol. vi., Nos. 2, 3; Vol. vii., No. 2; Vol. viii.; Vol. ix., Nos. 1, 2, 1905. Botanical Series, Vol. ii., No. 3, 1906. Geological Series, Vol. ii., No. 7; Vol. iii., No. 2, 1906. Report Series, Vol. ii., No. 5, 1905. Zoological Series, Vol. vi.; Vol. vii., No. 1, 1905. *The Museum*

University of Chicago. Astrophysical Journal, Vol. xxii., Nos. 3 - 5, 1905; Vol. xxiii., Nos. 1 - 5; Vol. xxiv., Nos. 1, 2, 1906. Journal of Geology, Vol. xiii., Nos. 7. 8, 1905; Vol. xiv., Nos. 1 - 6, 1906. *The University*

Western Society of Engineers. Journal, Vol. x., Nos. 4 - 6, 1905; Vol. xi., Nos. 1 - 4, 1906. *The Society*

CHRISTIANIA—Norwegische Meteorologische Institute. Jahrbuch für 1903. *The Institute*

Videnskabs-Selskabet i Christiania. Forhandlinger, Aar 1904-5. Skrifter, 1904-5. *The Society*

CINCINNATI—Cincinnati Society of Natural History. Journal, Vol, xx., Nos. 5, 6, 7, 1906. *"*

Lloyd Library of Botany, Pharmacy and Materia Medica. Index of the Mycological Writings of C. G. Lloyd, Vol. i., 1898 - 1905. Mycological Notes, Nos. 19 - 21, 1905-6. Mycological Series, Bulletin, No. 8. *The Library*

University of Cincinnati. Illustrated Booklet. Record, Series I, Vol. ii., Nos. 3 - 15, 1905-6; Ser. II., Vol. ii., Nos. 1, 2, 1906. Teachers Bulletin, Ser. 3, Vol. i., No. 6; Vol. ii., No. 5, 1905. *The University*

COLUMBIA—University of Missouri. Laws Observatory, Bulletin, Nos. 2 - 7. Studies, Vol. i., No. 1, 1905. *"*

COPENHAGEN—Société Royale des Antiquaires du Nord. Mémoires, Nouvelle Série, 1904. *The Society*

CORDOBA—Académia Nacional de Ciencias. Boletin, Tomo xviii., Entrega 1, 2, 1905. *The Academy*

CRACOW—Académie des Sciences de Cracovie. Bulletin International, Classe de Philologie, Classe d'Histoire et de Philosophie, Nos. 3 - 10, 1905; Nos. 1 - 3, 1906. Catalogue of Polish Scientific Literature, Tom v., Zeszyt 1 - 4, 1905. Classe des Sciences Mathematiques et Naturelles Nos. 5 - 10, 1905; Nos. 1 - 3, 1906. *"*

DENVER—Colorado Scientific Society. Proceedings, Vol. viii., pp. 55 - 122. *The Society*

DES MOINES—Iowa Geological Survey. Annual Report for 1904, Vol. xv. *The Survey*

DRESDEN—Königl. Mineral-Geolog. Museum. Die Gastropoden der Sächsischen Kreideformation von Dr. Karl Deninger 1905. *The Museum*

Königl. Sächs. Statistische Bureau. Zeitschrift, Jahrgang li., Heft 1, 2, 1905. *The Bureau*

Königl. Sammlung für Kunst und Wissenschaft. Bericht über die Verwaltung und Vermehrung, 1902-3. *The Director*

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Vereins für Erdkunde zu Dresden. Bücherei-Verzeichnis, Abgeschlossen am 15 April, 1905. Jahresberichte, Band VI., 1898-1901. Mitglieder-Verzeichnis, April 1905, April 1906. Mitteilungen, Heft 1, 2, 1905; Heft 1, 1906. Muschelgeld-Studien von Prof. Dr. Oskar Schneider. Nach dem hinterlassenen Manuskript bearbeitet von Carl Ribbe, 1905. *The Society*

DUBLIN—Royal Dublin Society. Abstract of Minutes. Session 1905-6. Economic Proceedings, Vol. I., Parts vi., vii., 1905-6. Scientific Proceedings, Vol. X., N.S., Part iii., Vol. XI., N.S., Nos. 1-9, 1905-6. Scientific Transactions, Series 2, Vol. IX., Nos. 2, 3, 1906. „

Royal Irish Academy. List of Members, 1906. Proceedings Vol. XXV., Section B, No. 6, Section C, No. 12, 1905; Vol. XXVI., Section A, No. 1, Section B, Nos. 1-5, Section C, Nos. 1-9, 1906. Transactions, Vol. XXXIII., Section A, Part i; Section B, Parts i., ii., 1906. *The Academy*

EDINBURGH—Botanical Society of Edinburgh. Transactions and Proceedings, Vol. XXIII., Part i., 1905. *The Society*

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Royal Society. Proceedings, Vol. XXIV., Sessions 1901-3; Vol. XXV., Parts i., ii., 1903-5; Vol. XXVI., Nos. 1-4, 1906. Transactions, Vol. XL., Parts iii., iv., 1902-4; Vol. XLI., Parts i., ii., 1903-5; Vol. XLIII., 1905. „

University. The Edinburgh University Calendar, 1906-1907. *The University*

ELBERFELD—Naturwissenschaftliche Vereins. Jahres-Berichte, Heft XI., 1906 und Beilage. *The Society*

FLORENCE—Società di Studi Geografici e Coloniali in Firenze. Revista Geografica Italiana, Annata XII., Fasc. 8-10, 1905; Annata XIII., Fasc 1-7, 1906. *The Society*

Società Italiana d' Antropologia, Etnologia etc. Archivio, Vol. XXXV., Fasc, 2, 3, 1905; Vol. XXXVI., Fasc 1, 1906. „

FORT MONROE Va.—United States Artillery. Journal, Vol. XXIV., Nos. 1-3, Whole Nos. 74-76, 1905; Vol. XXV., Nos. 1-3, Whole Nos. 77-79, 1906; Vol. XXVI., No. 1, Whole No. 80, 1906. *The Artillery Board*

FRANKFURT a/M.—Senckenbergische Naturforschende Gesellschaft. Bericht, 1905. *The Society*

FREIBERG (Saxony)—Königlich-Sächsische Berg-Akademie. Jährbuch für das Berg-und Huttenwesen im Königreiche Sachsen, Jahrgang 1905. *The Academy*

FRIBOURG—Société Fribourgeoise des Sciences Naturelles. Bulletin, Vol. XII., 1903-4. *The Society*

GEELONG—Geelong Field Naturalists' Club. The Geelong Naturalist, Second Series, Vol. II., Nos. 2 - 4, 1905-6. *The Club*

GENEVA—Institut National Genevois. Bulletin, Tome XXXVI., 1905. Le Cinquantième Anniversaire de la Fondation de l'Institut Genevois, 1903. *The Institute*

GIESSEN—Oberhessische Gesellschaft für Natur-und Heilkunde. Bericht XXXIV., 1901 - 5. Medizinische Abteilung, Band I., 1906. *The Society*

GLASGOW—Royal Philosophical Society of Glasgow. Proceedings, Vol. XXXVI., 1904-5. "

University. The Glasgow University Calendar for the year 1906-7. *The University*

GÖTTINGEN—Königliche Gesellschaft der Wissenschaften zu Göttingen. Nachrichten, Geschaftliche Mittheilungen, Heft 2, 1905; Heft 1, 1906. Mathematisch-physikalische Klasse, Heft 4, 5, 1905; Heft 1, 2, 1906. *The Society*

GRATZ—Naturwissenschaftliche Vereins für Steiermark. Mitteilungen, Jahrgang 1905. "

HAARLEM—Koloniaal Museum te Haarlem. Bulletin, No. 34, 1906. *The Museum*

Musée Teyler. Archives, Série 2, Vol. IX., Parts iii., iv., 1905; Vol. X., Parts i., ii., 1905-6. "

Société Hollandaise des Sciences à Harlem. Archives Néerlandaises des Sciences Exactes et Naturelles, Série 2. Tome X., Liv. 5, 1905, Tome XI., Liv. 1 - 3, 1906. *The Society*

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PROCEEDINGS

OF THE

ENGINEERING SECTION.

PROCEEDINGS OF THE ENGINEERING SECTION.

(IN ABSTRACT.)

OFFICERS FOR 1906-7.

Chairman: J. HAYDON CARDEW, Assoc. M. Inst. C.E.

Hon. Secretary: NORMAN MCTAGGART, M.A., Assoc. M. Inst. C.E.

Committee: HENRY DEANE, M.A., M. Inst. C.E.
J. M. SMAIL, M. Inst. C.E.
T. H. HOUGHTON, M. Inst. C.E.
G. R. COWDERY, Assoc. M. Inst. C.E.
T. W. KEELE, M. Inst. C.E.
W. E. COOK, M.E., M. Inst. C.E.
NORMAN SELFE, M. Inst. C.E., M.I. Mech. E.
J. I. HAYCROFT, M.E., Assoc. M. Inst. C.E.
R. T. MCKAY, Assoc. M. Inst. C.E.
F. M. GUMMOW, M.C.E.
ALGERNON PEAKE, Assoc. M. Inst. C.E.

Past Chairmen: H. G. MCKINNEY, M.E. M. Inst. C.E.
S. H. BARRACLOUGH, B.E., Assoc. M. Inst. C.E.
J. DAVIS, M. Inst. C.E.

Session opened 16th May, 1906.

The officers for the Session were elected. In the absence from the colony of the chairman of the last Session (Mr. J. DAVIS) Mr. S. H. BARRACLOUGH welcomed the incoming chairman, who gave a brief address.

The discussion on Mr. SEAVER's paper on "The Storage and Regulation of Water for Irrigation Purposes" was proceeded with.

Mr. T. W. KEELE dealt first with the question of irrigation, especially in the County of Cumberland, and gave

statistics showing the advisableness of establishing such a system by utilising the waste waters of the Nepean River. These waste waters—or waters not required for the supply of Sydney—were shewn to be considerable, and by means of the existing canal could readily be applied to the soil at a cheap rate. Referring to masonry dams, Mr. KEELE doubted whether there is proper adhesion between the lower beds of the stones and the mortar, owing to the universal method of building such dams, the air being imprisoned beneath the stones. He showed photographs of the broken weir at Broughton's Pass in confirmation of this.

Messrs. F. M. GUMMOW, OSCAR SCHULTZ (by invitation), and H. C. KENT (Pres. Inst. Architects) also discussed the question.

20th June, 1906.

Mr. J. HAYDON CARDEW in the Chair.

Mr. W. E. COOK read a paper on "The washing and grading of Sand for Concrete," referring more particularly to the American experiments with unwashed sands, and with sand in which loam and clay are present.

Mr. F. M. GUMMOW gave some of the results arrived at by him after considerable attention to the matter of grading of sand. The washing of sand from broken sandstone is not only unnecessary and expensive but harmful, as all the small grains of silica are carried off, and all experiments shewed that pit sand should not be washed.

Mr. A. PEAKE gave the results of numerous tests which shewed that in almost every case the washed sand gave better results than the unwashed.

Messrs. J. H. CARDEW, H. D. WALSH, H. DEANE, and S. H. BARRACLOUGH also joined in the discussion.

18th July, 1906.

Mr. J. HAYDON CARDEW in the Chair.

Mr. H. D. WALSH read a paper entitled "Timber Wharf Construction." A review of the shipping and discharge arrangement in Sydney Harbour was given, together with the growth of wharf accommodation. The paper dealt mainly with timber piles and their enemies, the marine borers. The paper was illustrated by numerous specimens of portions of piles from old wharves, shewing the action of the *Teredo navalis* and marine insects. The author had also procured some of these marine borers and exhibited them on the table.

Messrs. T. W. KEELE, P. ALLEN, J. FERRIER (Engineering Association), and P. W. SHAW also discussed the subject.

August 30th and September 3rd, 1906.

A CONVERSAZIONE in conjunction with the Engineering Association, the Electrical Association, and the Institute of Architects was held in lieu of the usual monthly meeting. The general idea was to have an interesting collection of exhibits, the special idea being to give members of the Section an opportunity of meeting the members of other Societies.

The hall of the Royal Society was brilliantly illuminated by exhibits of the Electrical Association. Along each side of the hall were tables, and these together with the reading desk were covered with exhibits, while plans and photographs of interesting works nearly obscured the book cases. The reading room and basement were also used. Considered only as an exhibition, it was of a nature to cause surprise at its variety, and the exhibits shown by each Society made a good show, while as a social gathering of engineers and architects it was more than a success.

Mr. NORMAN MACTAGGART (in the absence of the Chairman) gave a short address, welcoming the other Societies to the Royal Society's House. During the year the Engineering Association, and the Institute of Architects had made the Royal Society's building their head quarters, and he hoped that extra accommodation would be provided so that the Electrical Association could also have rooms. All three Societies held their meetings here, and in the name of the Engineering Section of the Royal Society he welcomed them to this house.

19th September, 1906.

Mr. T. H. HOUGHTON in the Chair.

Mr. R. T. MCKAY read a paper on "The available Water derivable from gathering grounds, the loss, the reason for such loss, and the Relation between Rainfall and Discharge of the Murray River and its Tributaries." The paper was illustrated by numerous lantern slides of diagrams which showed the percentage of run off very clearly. After completing his paper, Mr. McKay showed a number of lantern slides of views of the various rivers in drought and flood, and of the engineering works constructed on them.

17th October, 1906.

Mr. J. HAYDON CARDEW in the Chair.

Mr. T. ROOKE read a paper entitled "Irrigation work in California and its relation to the transmission of electricity." The paper was accompanied by lantern slides illustrating the style of power houses and plant, the nature of the country in its natural state and under cultivation, and some of the details of the systems of irrigation adopted.

Mr. H. G. MCKINNEY said that we owe a great deal to America, who has shown us how irrigation can be carried

t successfully. Still what is possible in America might t necessarily be so here, owing to the difference in the nfiguration of the country. The Californian land as shown the screen was mountainous with swift running streams, hile the land to be irrigated in New South Wales was on e plains.

Mr. J. DAVIS agreed with Mr. McKinney as to the dis-milarity between the California and New South Wales and. He then referred to what is being done in the Vestern States of America. The desert lands belong to he Union, not to the States. In 1902 an act of Congress gave power to appropriate land revenues from 13 States and 3 territories for the purpose of making desert lands productive. There were now 11 projects in hand. The land was sold on time payment, at such a price that in 10 years the works would be paid for.

Messrs. ARNOTT, HOUGHTON and the Chairman contributed to the discussion.

21st November, 1906.

Mr. J. HAYDON CARDEW in the chair.

Mr. J. NANGLE read a short paper on "Australian Hardwoods." The author prefaced his paper with lantern slides of sections of various timbers, explaining the characteristics of each. He said he made these sections to establish, if possible, a system by which any of the *Eucalypti* could be identified by the engineer and architect who only had sawn beams placed before him. Unless he were an expert, an engineer could not tell that the timber supplied was of the variety demanded in the specification.

Mr. J. H. MAIDEN gave a most interesting addition to the subject. He said that the inherent difficulty in dealing with the *Eucalypti* is the size of the genus, and the

remarkable similarity between one species and another. Then each species has members differing more and more from the "type" adopted for that species until it overlaps the members of another species, and some trees may perhaps be looked upon as a variety of either of two contiguous species. Then it had been absolutely and scientifically proved that hybridism exists among the *Eucalypti*, and it is impossible to say where the tangled hybrids end.

Remarks were also made by Messrs. NORMAN SELFE, H. G. MCKINNEY, W. E. COOK, and the Chairman.

WASHING AND GRADING SAND FOR CONCRETE.

By W. E. Cook, M.C.E., M. Inst. C.E.

[*Read before the Engineering Section of the Royal Society of N. S. Wales, June 20, 1906.*]

In specifications for concrete the various proportions by measure are generally given, the second item being clean sharp sand, and sometimes the word "coarse" is used also. The object is to produce a mortar sufficient in quantity to fill the voids and leave some excess. Clean sharp sand, whether coarse or fine, may not be the best material for forming a solid mass, or for giving the greatest tensile and crushing strength, and the author has collected some information on the subject to place before the Engineering Section.

In 1900 Professor Sherman, of Ohio University, was building a viaduct in Yèllowstone Park, when it was found that clean sand and water for washing were not readily available. After some tests it was decided to use, without washing, a sand containing from 3 to 7% by volume of alkaline earth, organic matter, etc. Upon completion of the work some briquettes, made of cement and this unwashed sand, showed a higher tensile strength than briquettes made of same material after washing.

To test the matter further a series of tests, extending over 12 months, was made. Two kinds of cement were used and three kinds of sand, with mixtures of clay and loam, viz., 0, 2, 4, 6, 8, 10 and 15% by volume of total sand. The proportion was 1 part of cement to 3 parts of mixture of sand and clay, or loam. The three kinds of sand used were crushed quartz (reduced to standard), lake sand washed, and bank sand. The clay was first dried and ground in a ball mill. The loam was common soil obtained

from the field on the State University Grounds. This was ground in the same way that the clay was. It was found to have no hydraulic properties.

As each kind of cement was used with each kind of sand and also with the same proportions of loam and of clay, there were 12 sets of curves, showing strength up to 12 months. Arranging the diagrams in the order indicated, some interesting conclusions may be drawn.

Composition of briquettes.	Lehigh Bank Clay	Dyck Bank Clay	Lehigh Standard Clay	Dyck Standard Clay	Lehigh Lake Clay	Dyck Lake Clay
lbs. per sq. in.	625	560	550	500	500	425

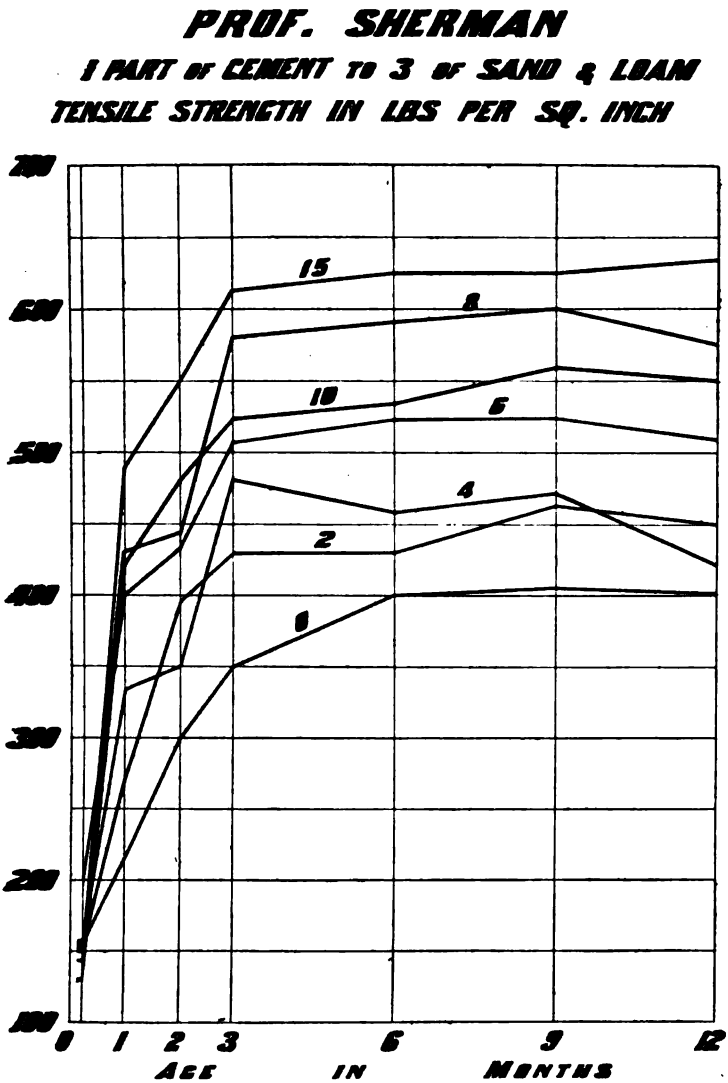
Composition of briquettes.	Lehigh Bank Loam	Dyck Bank Loam	Lehigh Standard Loam	Dyck Standard Loam	Lehigh Lake Loam	Dyck Lake Loam
lbs. per sq. in.	650	550	525	450	450	400

It will be seen that the strengths of the clay and loam briquettes are almost the same, and that Lehigh cement tests stronger than the Dyckenhoff in each combination, as it did in the neat briquettes. The bank sand also proved stronger at each combination than either the standard or lake sands.

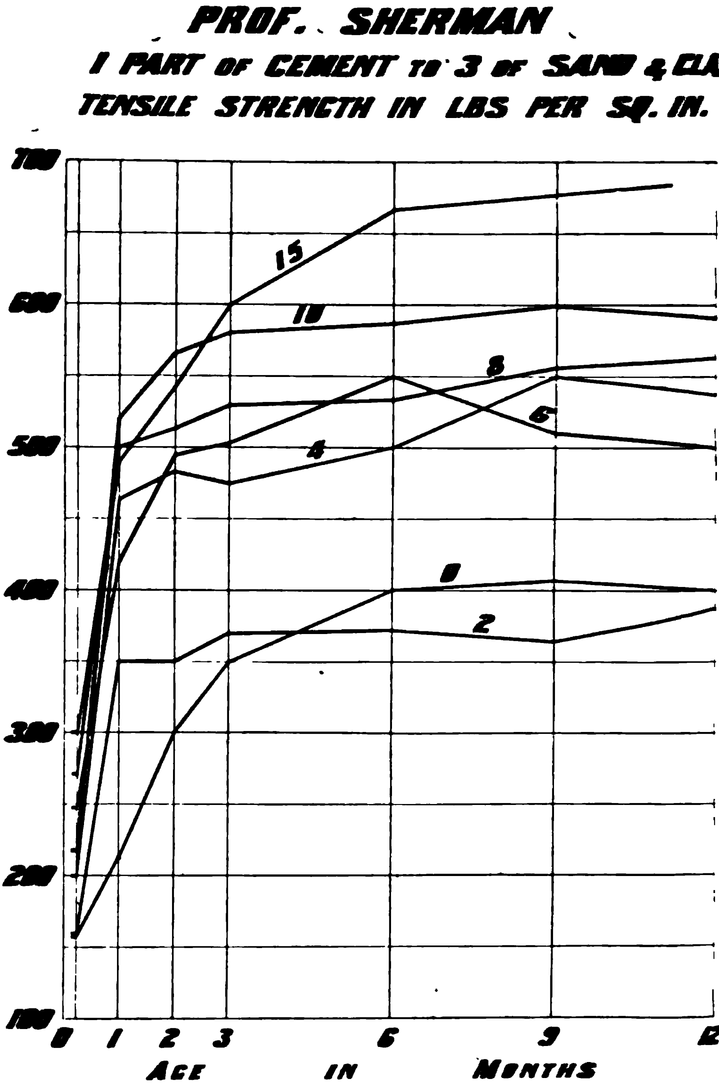
In 72 curves representing cement, sand, and clay or loam only 5 fell below the zero per cent., and the 15% mixture of clay or loam proved to be the strongest in 8 out of 12 cases at the end of the year. It seems reasonable to conclude, therefore, that clay or loam up to 15% is beneficial to cement mortar. However, the disadvantage of using a high per centage of loam or clay in mortar to be immersed, must be kept in mind. If the mortar is to be placed immediately under water, more than 8% would cause some trouble, as it takes longer to reach its final set.

The writer states that he is satisfied that time and money spent in washing sand for Portland cement concrete is wasted, and that the importing of lake sand, frequently specified at many places, is unnecessary. The writer also

draws attention to a paper by Mr. E. C. Clarke[1] in Vol. xiv. of the Transactions of the American Society of Engineers, in which he reported that 10% of loam, used with clean sand and Rosendale cement, did not decrease the strength



[1] Engineering News, 19tn Nov., 1903.



after six months or one year. Two diagrams are copied showing—(1) The curves of cement standard sand and clay; and (2) The curves of cement standard sand and loam. It will be seen that generally the higher the percentage of clay or loam, the greater the strength.

The following is an abstract from a paper on "Quality of Sand for Cement Mortar," by Mr. J. C. Hain, Engineer of Masonry Construction, Chicago, Milwaukee, and St. Paul Railway, read at Indianapolis[2]:—

"The Bridge Department of the Chicago, Milwaukee and St. Paul Railway requires large quantities of sand every year, from numerous sources, on its system of 7000 miles. It was therefore important to choose the shortest length of haul, and this led to the examination of a number of questionable sands. In many instances the results were a great surprise.

"In making the tests a mixture of 1 of cement to 3 of sand, by weight, was used throughout. Each result given represents the average of three tensile tests. The different sands tested were grouped, and each variety was tested with different Portland cements, and compared with a sample of standard St. Paul sand. One of the sands tested contained foreign material, resembling clay. The damp sand, when taken from the face of the bank, was plastic and readily caked in the hand like putty. A coating of fine material clung to the hand after handling it. Laboratory tests, extending over three years, were made. The results proved that the sand was superior in every way to the standard sand. The 7 day and 28 day tests were respectively 40% and 30% above the standard. The difference became less with age, although the 3 year test was still 20% above the standard. The sand tested so well that it was thought safe to use it for ordinary concrete. The question of using it under water, where clay might retard setting, was not gone into.

"Two other sands from one pit, the first being selected as the best sand in the pit, and the other as being the worst, were both considered doubtful, but tests proved both were

[2] Abstract Proceedings of Inst., &c., Vol. CLXI.

good. The first sample, which contained 3·2% of clay, gave lower tests than the second sample, which contained 15% of clay. Another test which proved the superiority of sand containing clay, was carried out in a different way. Two samples of the same sand were taken, one being washed and the other not. The unwashed sand proved about 25% superior, although it contained 6% of clay. Many other tests were made, which tended to prove that the presence of small percentages of clay is not objectionable, but on the other hand may be desirable.

"They did not prove, however, that sand containing ordinary soil would be better than sand without it, and tests were therefore made of washed sand, to which was artificially added 2, 5, 10, and 20 per cent of rich surface soil, consisting principally of decayed organic matter. The soil was taken from the bank of the Chicago River, where undisturbed weeds decomposed, season after season, and made the richest kind of soil. The results were disappointing. They were neither inferior nor superior, but proved quite irregular. The tests up to 2 years showed that at some periods they were above the sand containing no soil, while at other times they were below. The percentage of soil added did not cause the tests to follow any definite law. The 20% adulteration had but little different effect from the 2% adulteration. As a whole the average strength of the tests up to 2 years was about the same as the clean tests; but the irregularity was so great as to make the adulterated sands less desirable than the clean sands."

Mr. Hain[1] remarks that the strength obtained from a given sand depends to a considerable extent on the proper admixture of the fine and coarse particles. In conclusion he states that the best mortar sand found in nature is one with sharp corners, rough surfaces, grains neither coarse,

[1] Railway and Engineering Review, Chicago, 21st Jan., 1905, page 40.

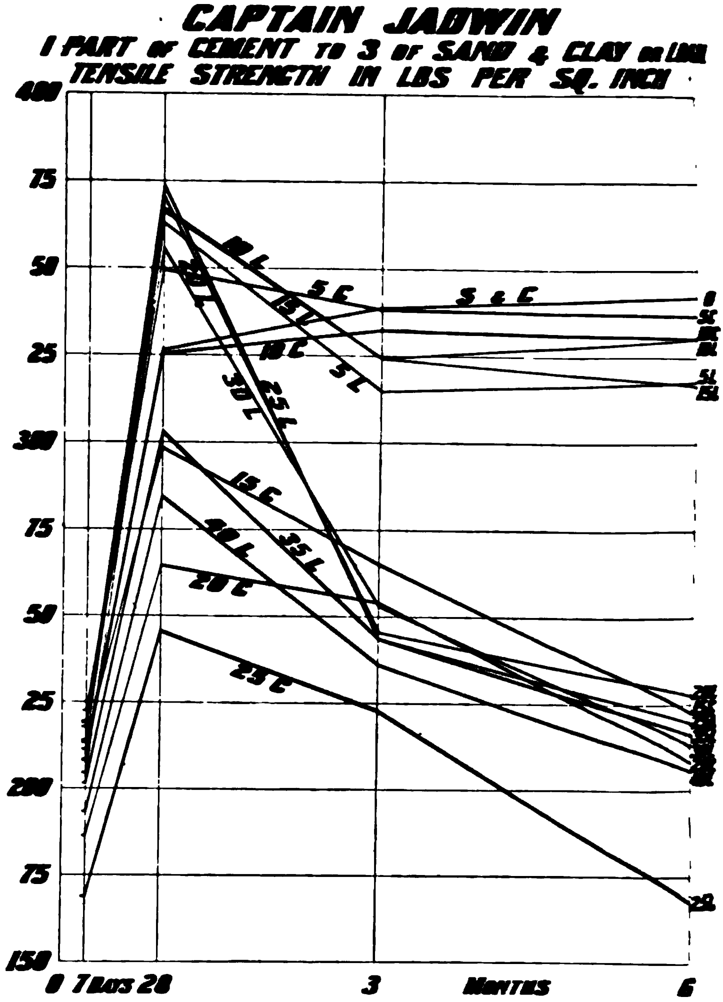
medium, nor fine, but with a mixture of particles of all sizes, and that the sand should not be washed, but may contain up to 12% of clay, which will not injure but, perhaps, improve it."

The following is an extract from a report on "Results of tests made to determine the strength of concrete when cement is mixed with sand and clay, or loam, in varying proportions." The extract was from a report on the "Defences of Galveston, Texas," by the officer in charge, Captain Edgar Jadwin, Corps of Engineers, to the Chief of Engineers, printed in the Report of the Chief of Engineers for 1905.[1] The cement used was "Double Anchor" brand, the sand standard quality; the clay was taken from the cutter of a dredge, working in Galveston channel; the loam was heavy black soil from the mainland. Both loam and clay were thoroughly pulverized, free apparently from all vegetable matter and sand, and sifted to remove lumps. All briquettes were made from one sample on the same day, under same conditions. The clay acted so unsatisfactorily during the working of the 25% batch, that no more briquetttes were made, but the loam was continued to 40%.

It will be seen from the diagram that at 3 months the standard sand and cement mixture was strongest and remained so, that 10% clay was almost the same as standard at 28 days, and that 5% clay and 5, 10 and 15% loam, were all well above standard at 28 days, but fell very rapidly, so that at 3 months they had all fallen below the standard, and afterwards maintained about the same strength, while the standard went on improving.

These results do not bear out Professor Sherman's, though they seem to have been very carefully conducted. Compare the results of Professor Sherman and Mr. Hain. The latter agrees with the former as to admixture of clay

[1] Engineering News, 27th February, 1906.



with sand up to 12% producing stronger briquettes than standard sand, but he does not agree that soil or loam does the same, and he concludes that sand so adulterated is less desirable than clean sand. He goes on to state that the best mortar sand is a graded one.

When we come to compare Professor Sherman's results with Captain Jadwin's, a very marked difference is observed and one is forced to the conclusion that the kind of clay, or so called loam, is a factor in the results. At the same time even Captain Jadwin's results show that an admixture of 10% clay and 15% loam is not much inferior to the standard sand.

No doubt washing sand removes not only the clay or vegetable matter, but also the fine sand particles, and the resulting mortar is not so solid. It is clear from above experiments that rich soil, resulting from decayed vegetable matter, should at least be removed from concrete sand.

In connection with the water supply works, Penzance, F. Latham, M. Inst. C.E., among other tests made the following experiment:—Ten briquettes were made with material taken from the works. In some cases the materials were carefully measured in accordance with the stereotyped specifications (1 of cement and 4 of sand, &c.), and in others care and judgment were used, placing a little finer sand in the mixture, and a larger proportion of sand to fill up the voids in the gravel.

The briquettes were proportioned 1 to 7 of aggregate, and the result was that the 1 to 7 briquette stood 115lbs. tensile strain, and the other stereotyped mixture, in the proportion of 1 to 4, stood but 45lbs., after 21 days immersion in water in each case.

On examining the careful gauging of 1 to 7, and comparing it with samples containing the higher percentage of cement, it was observed that there was an appearance of excess of cement showing on the trowelled surface of the former, and insufficient cement in the latter, although the proportions in which the cement was actually used were the reverse.

The above results show clearly the great advantage of grading the sand carefully, so as to produce a solid aggregate.

When the specification for the main outfall sewer was being prepared in Melbourne, in 1891, the difficulty of obtaining sand suitable for concrete forced itself on the attention of the Engineer in Chief, and accordingly a number of experiments were made with bluestone toppings in lieu of sand. The results of both tensile and crushing tests showed that the substitution was not only feasible, but advantageous.

TENSILE STRAINS,

Material.	Proportion.	Age.	Breaking Strain
Bluestone Toppings	... 2 to 1	... 15 days	... 317lbs.
Beaconsfield Sand	... 2 to 1	... 8 ,,	... 160 ,,
Frankston Sand	... 2 to 1	... 8½ ,,	... 154 ,,
Bluestone Toppings	... 3 to 1	... 15 ,,	... 346 ,,
Beaconsfield Sand	... 3 to 1	... 7 ,,	... 68 ,,

The age was in favour of the briquettes made with toppings, but the gain between 8 or 9 days and 15 days would not bring the sand briquettes up to anything like the toppings.

As the concrete was to be practically always in compression, the crushing tests were made much more numerous. All proportions from 1 to 1 of sand or toppings, to 1 to 15 of sand or toppings, were tried, and it was found that the strength of the sand blocks varied from 84½ tons for 1 to 1, to 3 tons per square foot for 1 to 15; while in the case of toppings the variation was 168 to 12 tons, *i.e.*, toppings blocks were twice as strong as sand blocks in the 1 to 1 mixture, and 4 times as strong in the 1 to 15 mixture. Various mixtures of cement, sand or toppings, and screenings were then tried, with the result that the toppings still showed a superiority, but not so marked as in the first

set of experiments. All the figures need not be quoted, but the mixture finally adopted was 1 cement, 2 toppings, and 2 of ½-inch screenings. The crushing strain of this was 105½ tons per square foot at age of 50 days, as compared with 85 tons when using sand in lieu of toppings. The full mixture finally adopted was the above, with 3 parts of 2 inch bluestone. This gave a crushing strain of 99 tons per square foot. This is a splendid example of well graded materials forming a strong aggregate.

Paper read before the Victorian Institute of Engineers, by C. E. Oliver, C.E., October 2nd, 1889.[1]

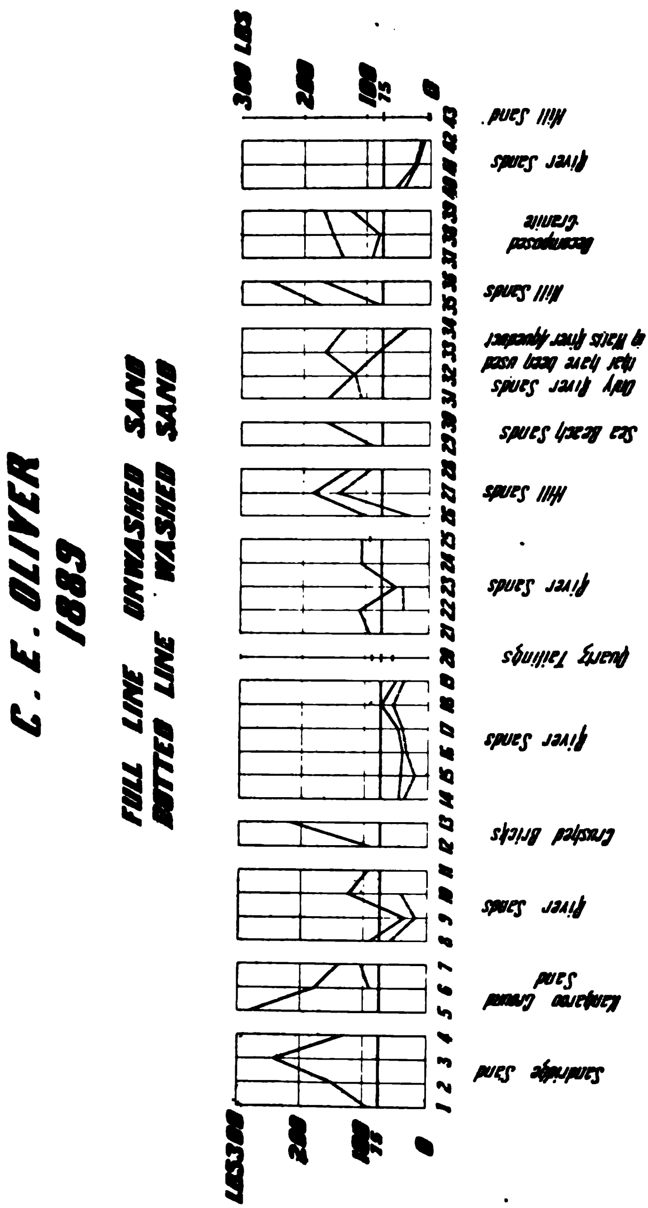
Sand.—" The results are all the average of 5 briquettes, broken at 1 square inch, made with the same cement, and mixed in proportion of 1 part cement to 2 parts by measure of the sand to be tested, and broken at the age of 7 days. The full line on diagram shows the strength in lbs. per sq. inch of the unwashed samples, whilst the dotted lines give that of the washed samples of the same sand. Nos. 1 to 4 are Sandridge sands of different degrees of coarseness, No. 3 being much the coarsest. No. 5 to 7 are from the top of a hill near Kangaroo Ground. No. 6, you will observe, stood 170lbs. per square inch unwashed, and washed (some 36 per cent. being washed away) only stood 87lbs. This sample was the first sand in which I found a result so at variance to the often expressed rule for sand for mortar or concrete, viz., ' that the sand used must be clean, sharp and washed.' Several sands from rivers and creeks gave the same results, though in general all river sands require washing, whilst hill sands do not. Nos. 8 to 11 show examples of river sand. Five samples of crushed brick are next shown, No. 12 being a soft brick and No. 13 very hard. Nos. 14 to 19 are river or creek sands, which seemed to the eye better than the hill sands 5 to 7. No.

[1] Building and Engineering Journal, 12th October, 1889.

20 is quartz tailings. Nos. 21 to 25 are samples of river sands, and Nos. 26 to 28 hill sands, which still show how much injury may be done to the mortar by washing the sand. Nos. 29 and 30 are sea beach sands. Nos. 31 to 34 are the only river sands which have been, and are being used on the Watts' River Aqueduct. These samples are interesting as showing in No. 31, one which it would have been detrimental to wash, No. 32 one in which it did not make any difference to the result if the sand were washed or not, and Nos. 33 and 34 are samples of sand for the washing of which a large steam plant was erected. Nos. 35 and 36 are the only exceptions I have had of hill sands requiring washing. Nos. 37 to 39 are decomposed granite, and a more unpromising looking sample one can hardly find, yet it stood when washed a fair strain, whilst Nos. 40 to 43 show how very worthless some sands are, although appearing good to the eye. In general the hill sands are, as is apparent, much superior to the river sand. The red line in the diagram represents the standard (75lbs. per square inch) that was adopted for the sand to come up to, in order to be accepted, all below being rejected.

From the diagram it will be seen that of 8 tests with hill sands two only, viz., 35 and 36, showed improvement by washing. When the river sand tests are examined, it is found that in 13 cases out of 19 where the samples were tested, both washed and unwashed, the unwashed sands gave better results than the washed sands. This does not bear out Mr. Oliver's statement, that "in general all river sands require washing."

These experiments show clearly that in general washing hill sands deteriorates them, and that in some cases the same is the case with river sands. Attention might also be drawn to the fact that of 4 samples of Sandridge sand, the coarsest gave by far the best result.


C. E. OLIVER
1889
FULL LINE UNWASHED SAND
DOTTED LINE WASHED SAND
300 LBS
200
100
75
0

A test, somewhat on the same lines as the Melbourne experiments, was made in connection with a contract under the Water and Sewerage Board, Sydney, comparing the tensile strength of briquettes made with—

(*a*) 1 part cement to 1 standard sand.
(*b*) 1 „ „ „ 1 bluestone dust or toppings.
(*c*) 1 „ „ „ $\frac{3}{4}$ standard sand and $\frac{1}{4}$ bluestone dust or toppings.

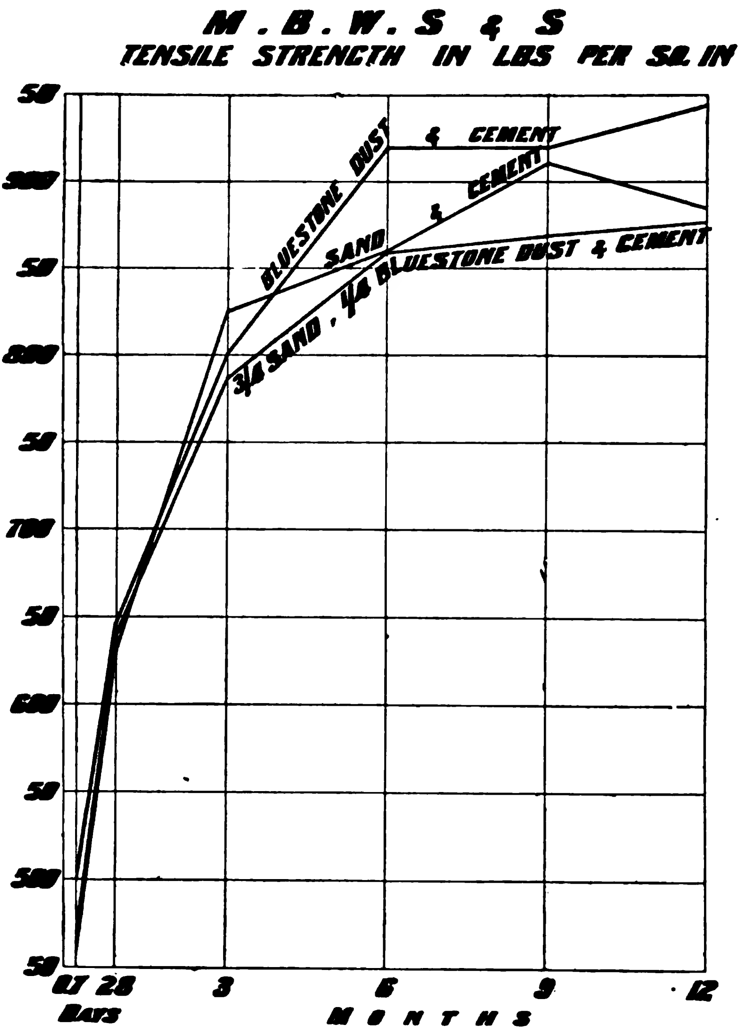
The results up to date are :—

Time.		Sand.		Bluestone Dust.		Sand and Bluestone Dust
7 days	...	460	...	501	...	464
28 „	...	631	...	647	...	639
3 months	...	825	...	801	...	787
6 „	...	860	...	920	...	859
9 „	...	911	...	920	...	869
12 „	...	885	...	944	...	877

Each test is the average breaking strain of 4 briquettes. They were all made on the same day, and were treated exactly alike. In this and all other briquette tests the briquettes, after being moulded, stay in the moulds 24 hours in the air; the moulds are then removed, and the briquettes are placed in water, and remain immersed until tested.

In this case the contractor was allowed to use $\frac{3}{4}$ sand and $\frac{1}{4}$ bluestone dust in place of each part of sand, because by careful sieving it was found that the stone, as delivered, contained dust to the extent of one quarter of the sand specified.

From the above figures, or from the diagram, it will be seen that bluestone dust is strongest throughout, except at three months. It should follow that the mixture of sand and dust is stronger than sand, but such is not the case; though at 7 and 28 days, and also at 6 and 12 months, there is practically no difference between the two. It is intended to continue this experiment up to 5 years.



The Melbourne and Sydney experiments should be accepted as conclusive proof of the superiority of bluestone dust to sand for use in concrete.

It may be of interest to give the results of washing and otherwise preparing two samples of crushed sandstone at the Water and Sewerage Board's testing room.

Yellow Coloured Sample.

Crushed sandstone, 729 cubic inches, weighed			37·2lbs.
Same sand washed, 668·25	,,	,,	34·2 ,,
Slime washed from 729 cubic inches 112	,,	,,	2·8 ,,
Lost in washing			0·2 ,,

The 34·2lbs. of washed sand consisted of—

3·8lbs. of coarse sand caught on ... 400 mesh sieve.
7·06 ,, standard ,, ,, 900 ,,
23·3 ,, fine ,, passed through 900 ,,

Lighter Coloured Sample.

Crushed sandstone, 729 cubic inches, weighed			37·2 lbs.
Same sand washed, 658	,,	,,	33·82 ,,
Slime washed from 729 cubic inches, 138	,,	,,	3·3 ,,
Lost in washing			0·08 ,,

The 33·8lbs. of washed sand consisted of—

3·18lbs. of coarse sand caught on ... 400 mesh sieve.
6·06 ,, standard ,, ,, ... 900 ,,
24·56 ,, fine ,, passed through 900 ,,

That is, only about 20% of the washed material was standard sand, or 18% of the original sample. And yet there does not appear to be much gain in strength by washing crushed sandstone, as the following experiments show:—

Briquettes made with standard sand, unwashed and washed samples of same crushed stone broke as follows:

	Standard.	Unwashed.	Washed.
7 days ...	213 ...	196 ...	207
28 ,, ...	336 ...	316 ...	333

Thus washed sand proved superior to unwashed by 5½% at both 7 and 28 days, and inferior to standard by 3% at 7 days, and less than 1% at 28 days.

These results are the average of seven tests. Again, taking the average results of 21 tests of unwashed crushed

sandstone, as compared with standard sand, the following figures were obtained:—

	Standard.	Unwashed.
7 days ...	220 ...	212
28 " ...	329 ...	316

or the unwashed samples proved only about 4% inferior in strength to the standard sand, both at 7 and at 28 days.

It may be mentioned that drift sand, from Bourke Street, Surry Hills, and from Double Bay is far inferior to crushed sandstone, either washed or unwashed, and therefore to standard sand, as the following table shows:

	Standard.	Nepean. Fine.	Nepean. Coarse.	George's River.	Neutral Bay. Sandstone.	Double Bay. Drift.	Surry Hills. Drift.
7 days ...	185	162	200	167	180	162	158
28 " ...	232	201	246	196	214	179	183
6 months...	353	263	320	232	341	208	214
12 " ...	333	255	300	230	322	198	221

The mixtures for the above were all made with the same cement on the same day. It will be seen that Neutral Bay crushed sandstone proved only slightly inferior to the standard, while two samples of drift sand were much weaker.

To test the strength of briquettes made with coarse and fine samples of sand, and obtained from same place, six tests were made in all from three different places. In every case, both at 7 and 28 days, the coarse samples gave the better results, the averages being—

	Coarse.	Fine.
7 days ...	213lbs. ...	174lbs.
28 " ...	271lbs. ...	248lbs.

so that, other things being equal, the word "coarse" should be included in the specification for sand for concrete, unless "carefully graded" are the words used.

These results were strictly in accordance with what might have been anticipated, from the fact that if all the

particles in the one case were of a certain diameter, and in the other case half that diameter, the interstices in the sand contained in a fixed volume would be the same in both cases, but the surface in the latter case would be six times as great as in the former.

Turning back to the figures showing volume of slime washed out of samples of crushed sandstone, it will be seen that the resulting slime washed out was 17% of the original volume, though the washed sand was 91% of that volume, taking the mean of the two sets of figures.

The material washed away from crushed sandstone we commonly call pipeclay, a material that is detrimental to sand, but at the same time it evidently serves to fill up the interstices, as, adding 125 cubic inches to 663 cubic inches results in a mixture only 729 cubic inches in volume in place of 788 cubic inches. The slight gain in strength obtained by washing crushed sandstone would probably be increased considerably if, in place of 125 cubic inches of slime washed out, we added an equal bulk of fine sharp sand, so as to have a graded mixture of good material, equal in bulk to the original sample.

It is quite clear that the clay and loam mentioned in the American experiments are better materials than the slime washed out of crushed sandstone, as washing the latter material clearly improves it, though only to the extent of 4 to 7 per cent. For most purposes the trouble and expense would more thancounter balance this gain, but for works where the strength of the concrete is important, washing should be specified in the case of crushed sandstone.

In August, 1901, the Engineer-in-Chief for the Water and Sewerage Board had experiments made to determine the voids in bluestone and sandstone of certain gauges, and in certain mixtures of them. In the hope that the

results may be of some use to members, the author has included them in the paper. The instructions given, and the results obtained, are tabulated below.

TESTS OF VOIDS IN BROKEN METAL.

Crown-street Depôt, 27/8/01.

Material for Tests.—Bluestone metal to be of a size to pass freely, with its largest dimension, through a ring 1½ inches diameter, and screened through a sieve of meshes ⅛ inch apart. Sandstone metal to be of a size to pass freely, with its largest dimension, through a ring 2 inches diameter, and screened through a sieve of meshes ¼ inch apart.

Method of Testing.—Each test shall be made three times in succession, and the mean of the three tests shall be considered correct.

1. Fill gauge with 1½ inch metal, then fill with water accurately measured.
2. Fill gauge with 2 inch metal, then fill with water accurately measured.
3. Mix 80% of 2 inch metal with 20% of 1½ inch metal.
4. " 80 " 1½ " " 20 " 2 "
5. " 60 " 2 " " 40 " 1½ "
6. " 60 " 1½ " " 40 " 2 "
7. " 50 " 2 " " 50 " 1½ "

   In each case place the metal in gauge and fill with water, accurately measuring the same.
8. Mix as much sand as possible with the gauged quantity of 2 inch metal, without increasing its bulk.
9. Mix as much sand as possible with the gauged quantity of 1½ inch metal, without increasing its bulk.
10. Mix as much sand as possible with 50% of 2 in. and 50% of 1½ inch, without increasing its bulk.
11. Interstitial space in sand used.

Gauge box for metal measured 4 ft. x 4ft. x 1ft. 6in.

Gauge box for sand measured 1ft. x 1ft. x 1ft.

Tests of Voids in Bluestone and Sandstone.

1. Water in $1\frac{1}{2}$ inch bluestone = 44·07%.
2. „ „ 2 inch sandstone = 35·57%.
3. „ „ mixture, 80% 2 inch sandstone and 20% $1\frac{1}{2}$ inch bluestone = 35·83%.
4. „ „ „ 20% 2 inch sandstone and 80% $1\frac{1}{2}$ inch bluestone = 41·3%.
5. „ „ „ 60% 2 inch sandstone and 40% $1\frac{1}{2}$ inch bluestone = 37·24%.
6. „ „ „ 40% 2 inch sandstone and 60% $1\frac{1}{2}$ inch bluestone = 38·48%.
7. „ „ „ 50% 2 inch sandstone and 50% $1\frac{1}{2}$ inch bluestone = 36·49%.
8. Sand in 2 inch sandstone, 33·67%.
9. „ $1\frac{1}{2}$ inch bluestone, 36·31%.
10. „ 50% 2 in. sandstone & 50% $1\frac{1}{2}$ in. bluestone, 32·11.
11. Water in sand used, 33·1%.

Perhaps it will not be out of place to quote an article by Lieutenant Sankey, published in "Engineering," 1st Sept., 1905, on the subject of voids in mixtures and the true proportions necessary to produce the best results, apart from the quality of the materials.

Lieutenant C. E. P. Sankey, R.E.
"Engineering," 1st Sept., 1905.

Lieutenant Sankey proposes that the specification for concrete might be worded somewhat as follows:—

"The percentage of voids in the selected aggregate is to be measured, and sand and cement are to be added to make a sufficient cement mortar of the quality × sand to 1 of cement, to fill the voids, + 20 per cent. Thus the procedure before starting to make concrete would be as follows:—

1. Settle upon the aggregate to be employed, both as to its nature and its gauge.

2. Measure the amount of contained sand in the aggregate, and this having been removed, determine the proportion of voids; observe also the quantity of water absorbed.

3. Choose the quality of cement to be employed in the work.

4. Calculate how much cement, sand, and water will be required for some definite amount of the aggregate—say a cubic yard—making allowance for the sand in the aggregate and the water absorbed.

5. Have boxes or measures made to contain the calculated amounts of cement and sand and water. In the case of water a margin, of say 10 to 20 per cent. overplus, should be allowed.

The following is a short description of a method for determining the voids, etc., in an aggregate:—

Obtain some water-tight receptacle with an arrangement at the bottom for letting water drain off. The size is immaterial, but the larger it is the more accurate will be the experiment, but also more difficult will be the apparatus to handle. Somewhere in the neighbourhood of half a cubic yard will be convenient. Call this the "tank."

Now find how many times (say n) some smaller receptacle, which may be called the bucket, is contained in the tank, which is most conveniently done by filling the tank with water, one bucketful at a time. The capacity of the bucket need not be determined, but it can be called q. Hence the capacity of the tank is $n\,q$. After letting off the water fill the tank with dry aggregate, without removing the contained sand. Now fill up the tank with water, and suppose it holds just w bucketsful before overflowing, sufficient time being allowed for the aggregate to absorb the water. Let off the water and fill up again, and say that the number of bucketsful is x.

Now completely empty the tank, and fill again with dry aggregate from which the sand has been screened, care being taken to pack the aggregate exactly as before.

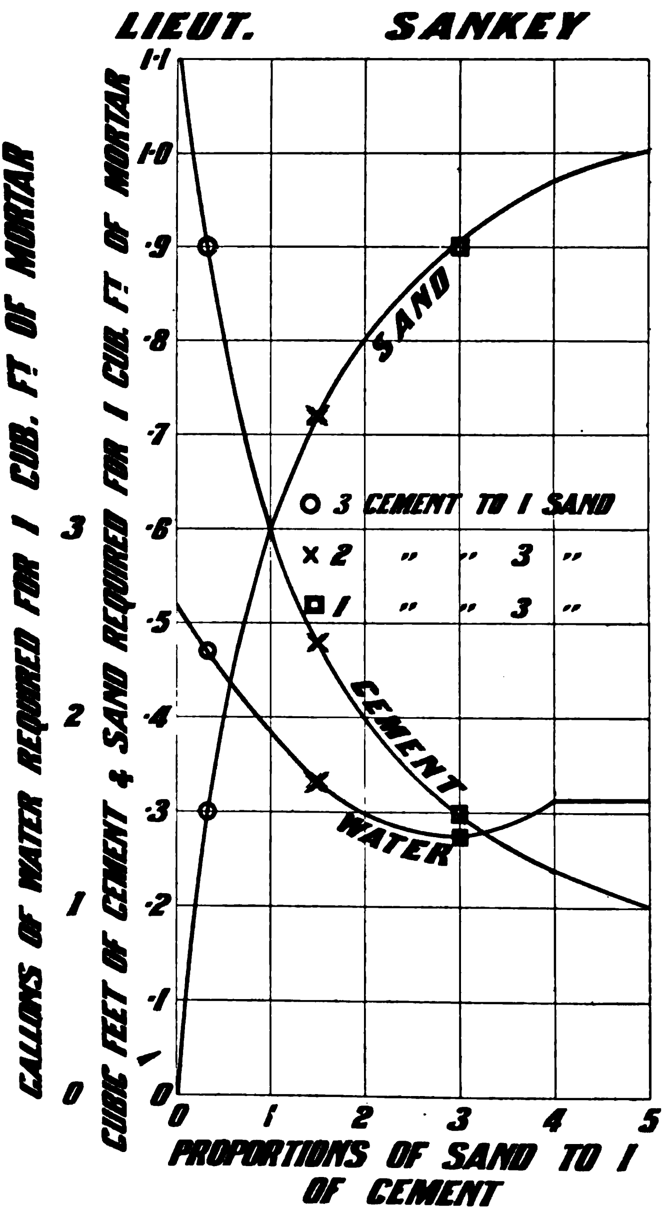
Again fill up with water, this time with y bucketsful (giving time for absorption), then let off the water, and fill again with z bucketsful.

From the data thus obtained the following deductions can be made:—Voids in nq cubic feet of wet aggregate, free from sand $= z\,q$ cubic feet. Therefore the aggregate has $100\,\frac{z}{n}$ per cent. of voids. Water absorbed by dry aggregate, free from sand, $= (y-z)\,q$ cubic feet, and therefore $100\,\frac{y-z}{n}$ is the percentage of water absorbed. Contained sand in $n\,q$ cubic feet of aggregate is $(z-x)\,q$ cubic feet, and therefore $100\,\frac{z-x}{n}$ is the percentage of contained sand. The actual quantity of cement, sand and water can be obtained by inspection from diagram, combined with simple calculations.

Thus, suppose an aggregate has 15% of sand, and when freed from sand has 40% of voids, and that it absorbs 15% of water, and that the concrete is to contain 1 of cement to 3 of sand, from diagram it will be seen that to produce 1 cubic foot of mortar of this quality, ·3 cubic feet of cement, ·9 cubic feet of sand, 1·35 gallons of water are needed. Further, 1 cubic yard, or 27 cubic feet of aggregate, requires $1{\cdot}2 \times 27 \times {\cdot}4 = 12{\cdot}96$ cubic feet of mortar to fill voids and give 20% over.

Required cement $= 12{\cdot}96 \times {\cdot}3 = 3{\cdot}89$ cubic feet per cubic yard of aggregate.

$$\left.\begin{array}{l}\text{Required water for mortar} \\ \qquad 12{\cdot}96 \times 1{\cdot}35 = 17{\cdot}50 \\ \quad \text{,,} \qquad \text{,,} \quad \text{absorbed} \\ \qquad 27 \times \frac{15}{100} \times 6\tfrac{1}{4} = 25{\cdot}3\end{array}\right\} \begin{array}{l}= 42{\cdot}8 \text{ gallons,} \\ \text{or say 50 gal-} \\ \text{lons to allow} \\ \text{for waste.}\end{array}$$


LIEUT. SANKEY
GALLONS OF WATER REQUIRED FOR 1 CUB. FT. OF MORTAR
CUBIC FEET OF CEMENT & SAND REQUIRED FOR 1 CUB. FT. OF MORTAR
0
1
2
3
0
·1
·2
·3
·4
·5
·6
·7
·8
·9
1·0
1·1
SAND
CEMENT
WATER
○ 3 CEMENT TO 1 SAND
× 2 " " 3 "
□ 1 " " 3 "
0
1
2
3
4
5
PROPORTIONS OF SAND TO 1 OF CEMENT

$$\text{Required sand} \quad \left.\begin{array}{r} 12{\cdot}96 \times {\cdot}9 = 11{\cdot}66 \\ -\dfrac{15}{100} \times 27 = -\ 4{\cdot}05 \end{array}\right\} = 7{\cdot}61 \text{ cubic ft.}$$

The quantities for any other proportions can readily be found.

In conclusion the author wishes to thank Mr. Thwaites, M. Inst. C.E., Engineer-in-Chief Metropolitan Board of Works, Melbourne, and Mr. Smail, M. Inst. C.E., Engineer-in-Chief, Water and Sewerage Board, Sydney, for their kindness in placing at his disposal the information given in the paper concerning the experiments made in Melbourne and Sydney respectively.

Exhibits of standard sand, crushed sandstone washed, slime washed from same, Surry Hills sand, also broken briquettes made with bluestone dust, and with mixtures in lieu of sand, were placed upon the table.

NOTES ON WHARF CONSTRUCTION, SYDNEY HARBOUR.

By H. D. Walsh, B.A.I., T.C. *Dub.*, M. Inst. C.E.

[With Plates IX. – XI.]

[*Delivered to the Engineering Section of the Royal Society of N. S. Wales, 18th July, 1906.*]

As the wharf construction and the accompanying shipping appliances in any port is of course governed by the class of ships likely to visit that port, I propose in the first instance to give a brief sketch of the growth of the trade in the port and the steps taken from time to time to provide for the berthing and discharge of vessels trading to Sydney. The earlier records of the Colony do not furnish any figures

of the shipping which visited the various ports in the year 1800, but in 1822 the ports of New South Wales, which then represented the whole of Australia, were visited by 71 vessels of 22,824 tons in the aggregate. In 1830 the number increased to 157 vessels of 31,225 tons; by the year 1840 the shipping had increased to 709 vessels, with an aggregate tonnage of 178,958 tons. The records show that the shipping entered at the port of Sydney in 1860 numbered 852 of an aggregate tonnage of 292,213.

In 1870	numbered	1,006	of an aggregate	tonnage of	385,161
1880	,,	1,277	,,	,,	837,738
1890	,,	1,525	,,	,,	1,644,539
1900	,,	1,819	,,	,,	2,716,651
1901	,,	1,834	,,	,,	2,953,511
1902	,,	3,722	,,	,,	4,101,291
1903	,,	6,093	,,	,,	4,226,954
1904	,,	7,554	,,	,,	4,754,550
1905	,,	9,626	,,	,,	5,681,071

From this it will be seen that in 45 years the shipping entering the port of Sydney had increased from 852 vessels, of an aggregate tonnage of a little more than a quarter of a million, to the very large number of 9,626 with an aggregate tonnage of over five and two-thirds million, thus making the port of Sydney one of the ten largest shipping centres of the world. The increase in the size of vessels visiting the port is also remarkable, and is of course the result of an evolution which has taken place the world over in the construction of both cargo and passenger carriers.

In the year 1870 a vessel of 3,000 tons was regarded as exceptional, and very few steamers of that size were engaged anywhere except between Liverpool and New York. Almost up to the middle of the seventies practically the whole of the over-sea trade of Sydney was carried in wooden sailing ships, ranging from a length of 180 feet, to

the then considered monster the "Sobraon," 272 feet long. These vessels to the number of ten to fifteen at a time used to lie principally round the Circular Quay parallel with the shore. Though Sydney Harbour used to be described as an ideal port, with deep water right up to the shore, that belonged to a shipping era prior to 1860, for the fine clipper ships of the sixties could not come within 50 or 60 feet of the wall at the Circular Quay. They were therefore moored some distance off with a network of chains, and a heavy staging, often 70 feet long, was rigged from the Quay wall to the side of the ship. These stages were built of a pair of piles with 6 inch by 6 inch bearers lashed crosswise underneath and 6 inch by 2 inch planks laid on the bearers. A donkey engine and winch stood on the shore, and the cargo was hoisted out of the hold, swung over to the rail and slid ashore on the staging. There were very few cargo sheds at that time, and it was consequently necessary to cart the goods away from the quay as quickly as they were landed.

In the year 1870 the wharfage accommodation of the port consisted principally of a stone sea-wall on the eastern and southern sides of Circular Quay, small timber wharves on the western side as far as Campbell's Wharf, and an irregular stone wall from Dawes to Miller's Point. Beyond the Gas Works in Darling Harbour were the A.S.N. Company's Jetties, about 150 feet long; the North Coastal wharves; the I.S.N. Company's Wharf; the Hunter River Company's and several other small jetties, all devoted to the coastal and intercolonial trade.

An era was marked in the shipping annals of the port with the advent of the iron ship. The limitations of timber construction had been a serious bar to the growth of the size of ships, but this having been removed by the adoption of iron construction, great strides were rapidly made. Of

course the changes did not at once effect so remote a port as Sydney. But in the early seventies the first four-masted vessel, the "Macgregor," arrived. She was an iron steamer 350 feet long, and for a time remained an object of wonder. She was followed shortly afterwards by the "Mikado," 386 ft. long. These two vessels were engaged to run the English Mail service viâ San Francisco, with Sydney as the terminus, Melbourne being then the terminus of the P. & O. Mail line. When the "Macgregor" and "Mikado" arrived, there was not a wharf in Sydney at which they could be properly berthed. They used to lie on the west side of Miller's Point and discharge the small quantity of cargo they carried over the usual long stages, or by means of lighters.

The "Macgregor" and "Mikado" were soon followed by the "Tartar," "Whampoa," and "Mongol," and it became clear in 1874 that some steps would have to be taken at once to remodel the shipping accommodation of the port. On one occasion the "Whampoa" took the ground at Dibbs' Wharf, and it was generally considered that she was much too large for the facilities afforded by this port. On the 25th of June, 1874, a Select Committee of the House was appointed to inquire into the wharfage accommodation and report thereon. At that period the wharfage was practically all private property, and the foreshores not having been laid out upon any comprehensive system, the difficulty in the way of keeping the berthing accommodation abreast of the times began at an early date to manifest itself. The chief disadvantage lay in the numerous small separate holdings which prevented proper access from the shore, and caused the projects of one owner to seriously interfere with those of another as far as the use of the waterway for jetties was concerned.

It is interesting to note the opinions regarding the future shipping requirements of the port as brought out in the

evidence given before the Select Committee. Schemes were advocated by the following gentlemen, Messrs. E. Moriarty, the then Engineer-in-Chief to the Public Works Department; Norman Selfe; J. Musson and Company and Thomas Woore. It is apparent from some of the statements made, that while the several schemes advocated by these gentlemen appeared at the time unduly extensive and costly, the enormous shipping developments that were shortly to follow, were more nearly anticipated by Mr. Selfe than by any of his contemporaries. Mr. Moriarty for instance, when giving evidence before the Committee said:—"On the western side of the Circular Quay there will be also two berths for vessels of that length (viz., 3?? feet) opposite the Commissiarat Stores; so that by this arrangement we can have four berths capable of taking in the largest ships that have ever visited this port *or are likely to visit it.*" Mr. Selfe, who appeared to stand alone in his opinions, advocated larger berths sufficient if necessary, "to berth the "Great Eastern" should she come here." It will thus be seen that very few engineers or persons interested in shipping, even at so late a date as 1874, appeared to realize the vast increase which within a very few years was to take place in shipping, or the necessity for making adequate provision for its accommodation.

In the year 1877 the arrival of the "Lusitania," the first Orient steamer, commenced a second era in the shipping history of the Port of Sydney. From this year the growth in the size of the vessels coming here became more and more rapid. The "Lusitania" was followed by the other larger Orient, P. and O, and German liners, the largest of which did not far exceed 6,000 tons. The arrival in 1897 of the Norddeutscher Lloyd's steamer "Barbarossa" of 10,800 tons, was a great advance, and marked another step in the

progress of the port, and being closely followed by others of similar tonnage, and of the Liverpool White Star liners of 12,000 tons, showed the necessity of at once providing suitable berthing accommodation for this class of vessel. The result was the construction of the extensive wharves at the east side of Woolloomooloo, completed in 1901. The fine wharf 1,280 feet long at Miller's Point, for the berthing of the two White Star liners, and the rearrangement of the west side of Circular Quay so as to provide a wharf 1,000 feet long for the Norddeutscher Lloyd Steamers; these latter wharves were completed by the Harbour Trust Commissioners in 1903, and in 1905 a jetty 500 feet long and 150 feet wide was constructed at Pyrmont for the wheat trade. This jetty will be extended to 1,000 feet long when required.

Contemporarily with the advent of these large vessels there has been a great increase in the size of all vessels engaged in both over-sea and coastal trade. Ocean tramps of 8,000 and 9,000 tons are now common enough, and even in the coastal and New Zealand trades, some of the vessels now range from 4,000 to 6,000 tons, whereas four or five years ago the largest was not much over 3,000 tons. This large increase in the size of steamers engaged in the New Zealand and Inter-State trade has necessitated the re-arrangement and enlargement of the majority of the jetties in Darling Harbour, and during the last few years many of the old structures have been removed and replaced by more up-to-date berths.

It will thus be seen that the requirements of the port as a shipping centre have been revolutionised within a single decade. Where formerly jetties 300 feet long with 80 to 90 feet of waterway between them sufficed, these are now quite inadequate for the accommodation of the present class of over-sea ship. On all sides we find the tendency

is to increase the length and tonnage of both cargo and passenger over-sea carriers; only last week it was announced that the Commonwealth Government had accepted a tender which provided for a line of steamers with a minimum tonnage of 11,000, to carry our mails between England and Australia in 636 hours, and it is also rumoured that another line of large cargo steamers will shortly enter the Australian trade. The limit of size in ocean going vessels has not, however, been reached yet by a considerable margin. The largest vessels at present visiting the port do not exceed 13,000 tons. Vessels are now being built for the Atlantic Service which reach upwards of 30,000 tons displacement and measure over 700 feet in length. Besides these monsters, the 13,000 ton White Star Liners which now come here are comparatively small.

Everything points towards another enormous advance in the size of vessels for which it will be necessary in the near future to provide berthing accommodation in Sydney Harbour. The longer the voyage, the greater the economy of the large vessel over the small one. The 30,000 tonner can be worked more cheaply per ton than two 15,000 ton ships. It is evident, then, in view of these probabilities, that we must look forward in our wharf construction to being able to meet such emergencies. With these facts before us, it is difficult to realise what class of berthing accommodation will be required 10 or 15 years hence; certainly the records of the past should warn engineers engaged in harbour construction, that, while the necessity for economy may make it impossible to do more than provide for present requirements, wharfage systems should be so designed as to allow of very large extensions and expansion in the future.

Wharf Construction.—The demolition of a number of old wharves and jetties, many of which were erected 30 to 40

years ago, has given me an exeeptionally good opportunity of closely observing the behaviour of the various classes of timber and other material used in their construction. It may have been noticed that timber for the construction of wharves and jetties still holds its own in Sydney, and it might be thought, seeing the extent to which iron and steel had displaced timber in ship building, that the same thing would have happened before this, in wharf construction. It might also be asked, if the wooden ship is obsolete, why not the wooden wharf also? In Europe there is some point in this question, because suitable timber is scarce and it is being rapidly superseded by steel, by re-inforced concrete structures, and by stone quay walls. In Sydney Harbour there are very few solid quay walls, the largest being the sea-wall at Darling Island and the privately owned wall at the Sydney Collieries, Balmain; there is also one of Monier sheet piling at the foot of Market Street. All the remaining public wharves having been constructed of timber. The reason for this preference for timber construction becomes evident as soon as the excellence of the material and the prime cost of construction are considered. In no other part of the world is to be found so plentiful a supply of good and suitable hardwood as in the forests of Australia. Owing to this fact, as long as the timber supply is available, wharf construction is more rapid, cheaper and more adaptable than under any other system.

During the iron age, that is before the present steel age, iron wharf construction was tried in Port Jackson. The iron wharf at the head of Darling Harbour erected by the Public Works Department in 1874, is a good example of this class. The high cost of construction and the very heavy cost of maintenance to protect it from corrosion, was however sufficient to prevent other wharves of similar design being constructed.

The leading objects to be considered in planning a wharf or a jetty, are sufficient deck area in relation to berthing space, combined with requisite strength and economy of cost. The earning power of a wharf is governed chiefly by two things: (*a*) the length of berthing space, (*b*) the capital cost; and it is in a proper adjustment of these two elements to one another, that the skill and forethought of the engineer become manifest. The commercial value of wharves and jetties in any part of the world can be fairly well compared on this basis. Regarding the cost of timber wharves and jetties per lineal foot and per square foot, no reliable rule can be laid down, as so much depends on the conditions of the foreshore, the amount of dredging, rock excavation, depth of the water, and the materials used.

Piles.—In timber wharf constructions the first consideration is a selection of the piles. This of course brings up the question of protection against marine borers. Sheathing with yellow metal, which practically doubles the cost of the piles, has not been so successful in point of durability, in recent years as it used to be, as I shall presently show. Nearly all the old private wharves from the head of Darling Harbour to Circular Quay were built of unsheathed turpentine piles of from 8 inches to 12 inches diameter. Though the exact dates of erection in some instances are not obtainable, the majority of them had been standing about 30, and one or two even 40 years. They were generally of light construction, having been built to suit the requirements of the time. It is interesting to note, that had it not been for the great increase in tonnage of ships in recent years, several of these old wharves might have been repaired and made serviceable for a few years more. Naturally some of the many piles drawn were found to be entirely crippled, but an examination showed that such were usually not turpentine timber.

I exhibit some sections cut from piles drawn from what used to be called "Smith's Wharf," Miller's Point, which has been replaced by a fine new wharf 1,200 feet long. These piles from outside indications when standing appeared to be amongst the most damaged of those in the wharf. The sections were taken from the worst looking portions of the piles, usually the two or three feet about low water mark. In three instances it will be seen that while the sapwood had entirely disappeared, having evidently been destroyed by *Sphaeroma* and *Limnoria terebans*, the timber itself is as sound as the day it went into place, only one of the three sections shows *Teredo* holes, and that not more than ten small ones, which would not materially weaken the pile. The fourth section, which as you see, is completely riddled with holes, is not turpentine, and has been classed as iron-bark. It may be added that about 80% of the old turpentine piles which were recently drawn from Smith's Wharf after a service varying up to 30 years, have been used over again for various purposes, such as sleepers for cargo shed floors, repairs to old wharves, etc. I may remark that the water in the vicinity of Miller's Point is in the line of the tidal current, and has always been comparatively free from sewage matter, so that pollution of the water can have exercised very little influence in preserving the piles from marine borers.

Touching upon more modern experience, I recently demolished a jetty in Woolloomooloo Bay, which had been standing 20 years. The piles were of unsheathed turpentine and proved to be so sound, that I used them again in additions to other wharves, such as Jones Brothers' coal wharf, Gillespie's wharf, etc. These piles showed only a few *Teredo* holes in the sapwood, and a little erosion at and below low water mark due to *Sphaeroma*. The water of Woolloomooloo Bay is of course out of the tidal current,

and has until recently, contained a considerable amount of sewage matter. It has been my experience that where the salt water is fouled to any great extent with sewage such as used to be the case at Woolloomooloo and at the head of Darling Harbour, before the low level sewerage scheme was brought into use, there is little or no danger to be apprehended from marine borers, as they do not seem to be able to live in water contaminated by sewage, although it is well known that the *Teredo* is more destructive in clean brackish water than in pure salt water. I recently drew some turpentine spring piles at the Circular Quay, driven twelve years ago; apart from a few *Teredo* holes in the sapwood, the timber was otherwise quite sound, and I used the piles again in the same position. The water in the vicinity used to be impregnated to a considerable extent with sewage matter. Apart from destruction by marine borers, turpentine piles are very durable and might be awarded a life of from 30 to 40 years.

From these and similar experiences which as you see are based on the test of a good many years, it appears certain that turpentine piles, unsheathed, are able to resist to a reasonable extent the attacks of marine borers in the latitude of Sydney. A little further north and in the Tropics I have no such faith in their immunity.

I have often remarked that of the total number of turpentine piles in a wharf, several, (say about 10%) will suffer badly from attack by marine borers, sometimes to the extent of complete destruction, while at the same time the others remain practically untouched. There are several possible explanations of this, amongst which I suggest the following:—

(1) A pile driven when green may conceivably, by retaining its sap, resist marine borers more effectually than one driven when dry.

(2) The season of the year at which the tree is felled may exercise an important influence through the amount of sap in the tree at the time of felling.

(3) The soil and latitude in which the trees are grown undoubtedly exercise a difference, but I have not sufficient data to specialise beyond the fact that there appear to be two kinds of turpentine tree, one having a thick and the other a thin bark.

(4) Turpentine piles are usually driven with the bark on, as the condition of the bark plays an important part in the preservation of the pile, those cut in summer retain the bark better than those cut in winter. Piles cut and hauled off without being allowed to lie for a couple of weeks on the ground suffer damage very easily to the bark. All turpentine piles should be allowed to remain on the ground long enough for the bark to become attached before being handled.

In Sydney Harbour, if not in other waters equally, the most serious ravages of marine borers are usually confined to the two or three feet about low water mark, and there are reasons to believe that in turpentine piles the damage is caused to a greater extent than is geuerally supposed by the *Limnoria* and *Sphaeroma*. There are instances in which years after a turpentine pile has been eaten through at low water mark by the *Sphaeroma*, the stump on being drawn has been found to be comparatively sound excepting perhaps for a few *Teredo* holes.

My opinion of the value of turpentine as a *Teredo*, *Sphaeroma* and *Limnoria* resisting timber in Sydney Harbour has received such confirmation that I have recently built several wharves of unsheathed turpentine piles, amongst which may be mentioned Dalgety's White Star Wharf at Miller's Point, 1,200 feet long by 40 feet wide, Howard Smith's Jetty 300 by 90 feet, the new Railway Jetty 500 by 150 feet, Tyser's

Wharf and others, and I confidently look forward to a life of 30 years for these wharves. Without taking into consideration the piles in the numerous small jetties and private structures, or those used in sheet piling along the foreshores (numbering probably 3,000), there are standing in Sydney Harbour some 7,000 unsheathed turpentine wharf piles; of these I have driven over 2,600 during the past 5 years. The majority of the remaining 4,400 have been standing from 20 to 30 years. In turpentine timber it is evident we possess a highly valuable element of wharf construction, which should be made the most of as long as it is procurable at a reasonable price.

I may here mention that with one exception, all the wharves in Circular Quay and Woolloomooloo are constructed of ironbark piles sheathed with yellow metal. These were constructed some years ago at a time when yellow metal could be relied upon as a safe protection for the piles, but as will be shown later on in this paper, sufficient reliance cannot now be placed in the metal procurable in this State, to warrant its use in this way. I regard ironbark when sheathed as the most durable of all our timbers for piles. Some time ago we took up the old Pyrmont Bridge, the piles of which were of ironbark sheathed with Muntz metal, and had been standing in salt water for 48 years, practically the whole of the piles which measure about 50 feet in length were sound, and I have driven them again in the construction of the new Pyrmont Bridge Wharf. The metal sheathing was upon the whole in bad condition, having disappeared in patches. But, owing probably to the amount of sewage in the water marine borers had not injured the timber to any appreciable extent. What remained of the sheathing was fairly good and testified to the good quality of the metal, as may be seen by the sample submitted. The heads of the piles for

about 18 inches down from the tenon were more or less decayed through the lodgement of organic matter in the crevices. If this had been prevented by weathering the tops of the piles or covering them with metal caps, it is probable that even this small deterioration would not have taken place. Apart from destruction by marine borers, ironbark piles, if protected at the head might be awarded a probable life of from 60 to 70 years. I exhibit a section cut from one of these piles. The sample shows no deterioration whatever after its immersion for 48 years in salt water.

Borers.—Having now described at some length the behaviour and durability of various piles examined in Sydney Harbour, a brief notice of the piles greatest enemies, the borers, may be of interest. In Sydney Harbour there are at least three kinds of borers which destroy unprotected timber piles. First in importance on account of the rapidity of its work, is the *Teredo* or ship worm. It attains to a considerable size, and when it fastens upon a class of timber to its taste, completely riddles it in a very short time. After the ship worm come the *Limnoria* and the *Sphaeroma*, the former is about the size of a grain of rice and bores the wood out into a minute honeycomb. It appears to have a decided predilection for soft wood, and is not a very serious menace to the timbers usually used for piles. The *Sphaeroma* is a larger creature, and in no way resembles either of the other borers. It does not appear to eat into the wood very deeply, but rather erodes the surface into small depressions which eventually run into one another. In time, with the assistance of the *Limnoria*, it would undoubtedly fret a pile right through, I think it is owing to the action of this creature on the surface that the *Teredo* holes become eventually visible, because the opening to a *Teredo* hole upon the surface is very small and not readily noticed. For further informa-

tion on marine borers I might refer to a valuable paper by Mr. C. Hedley, F.L.S.[1] I exhibit several specimens of the various borers; I have been unable to procure any large specimen of the *Teredo*, but may mention that in the brackish waters of the Myall Lakes and on some of the northern rivers I have seen *Teredo* quite 6 feet long and nearly three-quarters of an inch in diameter. The hard shell head which is said to act as a clutch to keep him up to his work is an interesting tool. It will be seen that the *Sphaeroma* greatly resembles the common or garden wood-louse, and I am informed that it belongs to the same family.

Yellow Metal.—The general experience of engineers during the last six or eight years has been that yellow metal sheathing is not as durable as it used to be. The sample taken from a pile of the old Pyrmont Bridge which has been immersed in sea-water for 48 years, though worn through in places is otherwise sound metal, fairly flexible, and polishes brightly. I have seen other samples proportionately good taken from piles in some of our coastal harbours which have been standing in the salt water for upwards of 25 years. On the other hand the sheathing of both vessels and piles with yellow metal has during the last few years been attended in many instances with conspicuous failure. Information of similar experiences has also come to me from Queensland and other States, and I am informed that complaints have latterly been so wide-spread that they have reached the manufacturers in England from all parts of the world. The manufacturers have stated that they are unable to afford any explanation of this sudden and rapid deterioration. Chemical analysis shows that the zinc in the alloy almost entirely disappears, leaving a brittle cellular copper skeleton. It has been suggested that the modern electrolytic process in the production of copper

[1] Journ. Austr. Assoc. Adv. Science, Vol. VIII.

whereby chemically pure copper is produced may have something to do with the rapid corrosion.

Advices from England recommended the trial of Navy brass, a sheathing made by the Muntz firm, and which consists of Muntz metal with 1% of tin added to harden it. This alloy being hard does not exfoliate on the surface like Muntz metal, and therefore fouls much more rapidly in sea-water. This however, is not an objection for pile sheathing. Navy brass is a little more costly than ordinary yellow metal. I am unable to afford any reliable information as to its durability, as it has only been recently placed on the market. I have heard however that it has shown but little superiority over the older brands. Coating the inside surface of the metal (that which goes next the pile) with coal tar has been found to protect the metal from corrosion set up by the juices from the wood.

Scantling.—Without doubt ironbark is the strongest and most durable of Australian timber suitable for caps and girders. Grey Gum and Brush Box are also excellent. Turpentine is a good timber and only a little less durable than ironbark, and also possesses the advantage of being less open to attack by white ant, but it has not the strength. The wharf at the eastern side of Cockatoo Island was built with turpentine piles, girders, and headstocks over 24 years ago. The headstocks and most of the girders are in good condition where the water has not found its way into the interior of the beams. The cause of rottenness in wharf girders—which always decay before the caps—arises from the opening of the grain by the deck spikes. A row of $\frac{1}{2}$ inch or $\frac{5}{8}$ inch spikes driven into a beam cause it to split in long cracks, especially when the work is done on green timber. Rain washes humus matter into these cracks and a rot is set up. To overcome this difficulty, I have adopted the use of malthoid damp course laid over each girder,

and tacked in place before the planking is put on. I am in hopes that this covering will prevent the rain water from saturating the beams through the cracks and also keep the humus matter from finding its way into the heart of the wood.

Decking.—For decking the two most durable timbers are Ironbark and Brush Box; the former is practically out of the question on account of high cost, Brush Box is however quite as good for the purpose, it does not shred and wears smooth and hard. The best results are obtained when a decking is laid of only one species of timber cramped close up, as the wear is more uniform. To lay planks of different durability indiscriminately, sometimes causes a very uneven surface, which cuts up much more quickly than when laid with less durable but uniform planking. To lay a deck only with Brush Box would cost more than using mixed hardwoods, because the waste Box from the mills is at present practically unsaleable, as when cut into small scantling, it has the reputation of warping badly. Diagonally laid decking lasts longer than the transverse method.

Land Ties.—I have adopted a method of tying the wharf back to the shore which has given complete satisfaction. The old system of bolting double 9 inch × 6 inch ties to the headstock, and the inshore ends to short piles with bearing logs in front, never proved satisfactory, and constant trouble was experienced, owing to the wood ends splitting open from the jar of vessels berthing. I now use old double-headed railway rails, linked together in such a way that they can only act in tension. These are fixed at the inshore end to concrete anchorages and each whole tie is then bedded in concrete to preserve it from oxidation. The land ties are therefore permanent.

Sea-walling.—Sea-walling has always proved an obstacle in connection with wharf construction, on account of the great cost of any kind of masonry or concrete work of sufficient weight to withstand the pressure of the earth and live load behind it, and in addition the strain of the vessels warping in. A concrete or masonry wall of gravity section, sufficient to afford a depth of 28 feet at low-water costs, even when a good rock foundation is found, at that depth, as much as £32 per linear foot of wall. This of course renders this style of wall construction practically impossible, except in special instances. Where a wharf runs parallel to the shore, and at the inshore end of all jetties, some kind of sea-wall is necessary. The wharves built in the seventies and eighties were usually backed by a ballast slope, with several courses of roughly squared stones at the top. The toe of the ballast slope standing at an angle of repose, 1 perpendicular to $1\frac{1}{4}$ horizontal, usually reached to the front line of the wharf, the depth being from 18 to 24 feet. This kind of wharf backing served its purpose well enough for many years, but as vessels grew in draught of water it became necessary to dredge the berths deeper and deeper. This process naturally caused the wharf backings to subside, and the toe of the ballast slope to extend beyond the front of the wharf, where it became a source of danger to the bilges of vessels. Many wharves built on this plan are still in use, as for instance, the older portion of the Woolloomooloo wharves; the wharves from Dawes' to Miller's Point, and several of the Darling Harbour wharves.

To cope with the difficulty of the subsidence of the old wharf backings, caused by the continual demand for deeper water, close sheet piling of turpentine was resorted to in many instances. The piles were driven to a sufficient depth to secure a hold, and the tops were tied back to

anchorages under ground. A certain measure of success attended this plan, but it had some serious defects. Round piles vary so much in diameter and straightness that they cannot be driven so close as to preserve contact throughout. Better results could certainly have been secured by siding the piles before driving, but this would have added considerably to the cost, and the removal of the bark and a part of the sap-wood would render the timber much more open to attack by marine borers than when driven intact with the bark on.

A wall of sheet piling formed of round logs standing vertically, though very cheap in construction, cheaper perhaps than any other that has ever been devised, has the fatal defect of being insanitary and affording a harbour for vermin. It presents a rough appearance, which perhaps would not matter so much, but in addition it furnishes an impregnable harbour for rats. As rats belong to the class of natural scavengers, and evidently consume a great deal of refuse that finds its way into every sea-port in spite of the vigilance of the authorities, there was not much objection to them until the plague broke out, and the source of infection was traced to the rats.

As a good deal of close sheet piling had been done along the shores of Darling Harbour, the question arose as to how the objection on the score of rat-harbourage could be got over. It occurred to me that if the sheet piling could be covered with anything that would present a straight clean front from the wharf level to low water mark, the difficulty would be surmounted. The solution was found in the use of "Monier Plates" hung in close contact all along the face of the sheet piling. The experiment was tried and found to be thoroughly successful. Up to the present time nearly 3,000 lineal feet of sea-walling has been treated in this way. The cost of a sea-wall so built

including land ties, and Monier plates runs from £4 to £6 per linear foot of wall, according to the depth of the water and other conditions. The Monier plates are made in several lengths to suit the various heights of the wharves. The lengths range from 9 feet to 12 feet 6 inches. They are 2 feet wide and 5 inches thick, being spared out in panels at the back to save weight.

Where the Monier plating occurs under a wharf, or jetty, they are bolted to horizontal walings, with 1¼ inch galvanized coach screws about 10 inches long, the attachment being thus a very simple process. Where the Monier plating stands as the exposed face of a wall, as for instance between two jetties, T-headed plates are used. They are simply dropped in between double walings and trim up against vertical wooden fenders, every 10 feet, so that they are protected both vertically and horizontally from being chafed by vessels. In one instance, at the foot of Market Street, where rock was met with at a reasonable depth, instead of using Monier-faced tupentine piles, Monier needles 27 feet long and 18 inches on the exposed face, were stepped into the rock below, and held back at the upper ends by walings and land ties.

It may be interesting to note that the total length of berthing space in Sydney, under the control of the Harbour Trust Commissioners, from Woolloomooloo to Darling Island, amounts to 39,236 linear feet, and that the shed storage capacity in connection with these wharves is equal to 373,200 tons. This shows a large amount of work done up to the present, but much important and interesting work will have to be carried out each year for many years to come, in order to keep the berthing and shed accomodation in line with the ever increasing tonnage which may be expected to visit our port.

In conclusion I wish to express my very best thanks to Mr. W. E. Adams, for his very valuable assistance in collecting the particulars from which these notes have been prepared, and for the help he has given me in arranging the various samples exhibited.

Description of Exhibits.

I have laid upon the table for examination some objects of interest which I have collected from time to time during the course of my work in Sydney Harbour. These consist of the following items:—

1. Two iron service bolts originally $\frac{7}{8}$ inch in diameter but reduced in the central portion by galvanic action to a diameter of about $\frac{1}{8}$ inch. These bolts were temporarily placed through double walings sheathed with yellow metal, and were withdrawn after having been two months in the salt water. These samples show the most rapid action of the kind that I have ever seen.

2. A portion of an ironbark pile and metal sheathing, already referred to, taken from the old Pyrmont Bridge after 48 years' of service. It will be seen that the timber is perfectly sound.

3. Tea-tree fascine from under the old Patent Slip which used to lie at the foot of King Street. This slip was laid in 1826, apparently on fascine, and I have no doubt but that this sample is 78 years old, having been preserved by the mud.

4. A portion of the slip-way from the same slip. I do not know for certain whether this is portion of the original way, but presume that it must be so. The timber having been bedded in the mud would last a long time. The slip went out of use in the early seventies, and it is not likely that it would have been repaired up to that time, as there were then no divers in Sydney. The only means of doing submarine work being a diving bell, owned by the A.S.N. Company.

5. Four sections of old piles from the demolished wharves on the west side of Miller's Point. These piles were standing about 30 years, *a* is from an unsheathed ironbark pile, and *b*, *c*, and *d*,

are from unsheathed turpentine piles. The value of the turpentine is here very apparent.

6. A longitudinal section cut from an unsheathed turpentine pile driven in Dalton's wharf in 1877, and drawn after 28 years' service. This sample illustrates what I have contended in the body of the paper, viz., that the most destructive borer to turpentine is not ship-worm but *Limnoria* and *Sphaeroma*. The large gap on the right hand side is the work of the *Limnoria*; the irregular erosion on the left side the action of the *Sphaeroma*. The cobra holes are insignificant. I might remark that Mr. Hedley, Conchologist at the Australian Museum, asserts in his article previously referred to in this paper, that the ship-worm in our waters is not quite the same as that which works so much destruction in European waters. He also expresses the opinion that the *Limnoria terebans* is probably not indigenous to these waters, but was originally imported by wooden ships trading here in the early days.

7. A longitudinal section of a blackbutt pile upwards of 50 years old, lately drawn from the head of Darling Harbour. This sample indicates that when the pile was driven the water, nearly as far up as the foot of Liverpool Street, was clean enough for the marine borers to be able to attack the timber. But after some years the water evidently became so greatly charged with sewage matter that the work of the borers was arrested. The deposit of dirt on the skin of this pile is very apparent when compared with sample No. 6, which was driven in clean water.

8. A portion of a yellow metal bolt drawn from the swing span of the old Pyrmont Bridge after 9 years' immersion in salt water. All the bolts drawn from the same structure and having been put in at the same time, were so brittle that they could not be got out without being broken in several pieces. This has been a common experience with yellow metal bolts in recent years.

9. Samples of yellow metal sheathing, showing conditions after various lengths of service.

10. A sample of zinc sheathing taken from the bottom of a pontoon at Circular Quay, after 12 year's service.

11. A portion of timber showing the size of the holes bored by *Cobra* at the head of the Myall River.

12. A portion of an oregon beam taken from Sydney Harbour, showing the destructive work of the *Limnoria*.

13. *Cobra* taken from piles in Sydney Harbour.

14. *Sphaeroma* taken from piles at Miller's Point.

THE AVAILABLE WATER DERIVABLE FROM GATHERING GROUNDS, THE LOSS, THE REASON FOR SUCH LOSS, AND THE RELATION BETWEEN RAINFALL AND DISCHARGE OF THE MURRAY RIVER AND ITS TRIBUTARIES.

By R. T. McKAY, Assoc. M. Inst. C.E.

[With Plates XXI. - XXII.]

[*Read before the Engineering Section of the Royal Society of N. S. Wales, September 19, 1906.*]

THE author has studied the problem of "Relation of Rainfall to Run-off" of the Australian rivers for many years. It became his duty as Secretary and Professional Assistant to the Interstate Royal Commission on the Murray River, appointed to inquire into the just allotment of the Murray River and its tributaries for the purposes of water conservation, navigation and irrigation, to investigate the questions forming the subject matter of this paper, so that the observations are based upon a personal knowledge of the country, a close study of the geological formation, climatic conditions, etc.

It is proposed to deal with the Murray River and its tributaries, which the author has traversed from mouth to

source in connection with investigations which have extended over a number of years.

The Basin of the Murray River.—The gathering grounds, (*Plate 21*) of this network of rivers, embrace an area of no less than 414,253 square miles, and probably no other portion of Australia presents a more interesting field for hydrographical research than the Murray Basin, wherein so many of the more remarkable and characteristic physical features of the continent are represented. It embraces the highest mountains and largest rivers in Australia. The Great Dividing Range, which forms its eastern and southern boundaries, commences in the Cape York Peninsula in Northern Queensland, and terminates close to the eastern border of South Australia, traversing New South Wales at a varying distance of from 30 to 130 miles from the coast. The Range attains its highest elevation near the southern boundary of the State where Mount Kosciusko reaches an altitude of 7,256 feet. The crest of this Dividing Range is narrow along the greater portion of its course, being only a few yards wide in places; but in some of the northern and southern portions, notably in the New England and Monaro Districts, it spreads out into extensive tablelands. There are numerous lateral ranges branching off from it, but none of these are of any considerable length, excepting one which leaves the main range and extends at right angles to it in a north-westerly direction, and forms the watershed between the tributaries of the Darling and Lachlan Rivers. On the north side of the range, running westward from the Dividing Range, lies the basin of the Darling with its numerous tributaries flowing from the range to the main river, and on the south is the basin of the Murray River. The low-lying portions of these basins consist of alluvial flats formed from the sediment brought down by flooded rivers, chiefly from the high slopes of the Dividing Range.

Influences affecting run-off.—The proportion of rainfall discharged by a stream varies according to the character of the catchment, whether it is mountainous, undulating or flat, the perviousness or imperviousness of the basin; the quantity and rate of rainfall and its distribution; the general geological formation of the country; atmospheric conditions; seepage, etc. The physical conditions affecting the run-off are so various, that it is impossible to formulate an even approximately correct rule as to the percentage of rainfall discharged from a gathering ground.

In accordance with the principle enunciated by Professor Gregory,[1] it is noticed that the interior of Australia receives most of its rain in summer, for then the currents of moist air are moving inland from the ocean. In winter, the conditions are reversed, for then the currents proceed from the interior to the coast and the air will be passing from a warmer to a colder area, thus causing its moisture to be condensed.

In a paper on "The cause of Rain, and the Structure of the Universe," Mr. Franz A. Velschow,[2] says:—

"That while the surface air is dry generally, we find it moister over a swampy place, as the sun and the warm and dry air which passes over it cause a strong evaporation to take place. The warm surface air, though expanded by heat, moves over the

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[1] Professor J. W. Gregory, D.Sc., F.R.S., The Climate of Australia—"It is a well known fact that water has a higher specific heat than land; that is, it requires more heat (the ratio is 5 to 1) to raise one pound of water one degree in temperature than to effect the same change in one pound of earth. Moreover, while water is more slowly heated on exposure to the sun, it gives off its heat more slowly. Thus, in the case of equal areas of land and water, each receiving precisely the same amount of heat from the sun, the land becomes the hotter during the day time, and cools the more quickly at night. As in the summer the days are longer than the nights, it follows that land will, on the whole, be warmer in summer and colder in winter than water adjacent to it."

[2] Trans. Am. Soc. Civil Eng., Vol. XXIII., 1890

ground without rising. It is first caused to ascend by being intermixed with the vapour particles. According to their buoyancy, the vapour particles tend upwards through the atmosphere, thereby carrying the air with which they are intermixed upwards also, and the ascent of a current of damp air is established. The vapour is the real cause of this motion, each and all of its particles acting as so many minute balloons. The ascending current after having passed through the heated surface air, gets suddenly into a much colder stratum, and condensation takes place by mixture of the rising damp air with cold air as it is passing through."

Coming in contact with the earth's surface, a portion of the rainfall is immediately absorbed by vegetation, a portion runs directly into streams, a portion is evaporated, a portion sinks into rock fissures and reappears in springs. As in the case of the artesian area of New South Wales, a considerable proportion is absorbed in the porous strata, thereby constituting a supply of great importance to the State in an area sadly deficient in running streams.

Summer Thunder-Storms in Australia.—With reference to the cause of rainfall, as stated in the foot-note below, a large percentage of the rain of Australia is precipitated in connection with storms of the last mentioned class. In the southern portion of Queensland, which forms the northern part of the drainage area of the Darling River, and in the Western Division of New South Wales, there are frequent visitations of cyclonic storms, often resulting in swelling the Darling, when the Murrumbidgee, Goulburn, and other rivers are diminishing in volume.

Professor Henry, Chief of the United States Weather Bureau: Rainfall of the United States.—"Cooling by expansion is one of the most effective causes of rainfall. The ascensional movement of air is brought about in several ways, chief of which are: (1) The air may be forced up the side of a mountain into a region of

diminished pressure and lower temperature, as happens whenever a mountain range runs in a direction at right angles to the prevailing winds. (2) In the warm season the lower layers of the atmosphere, under the effect of solar radiation and probably other causes, frequently reach a state of unstable equilibrium, thus inducing ascensional currents. Summer thunderstorms are largely a result of this process. (3) Last, and doubtless most important of all, is the circulation of the air in cyclonic storms, viz. a radial inflow from all sides and an ascensional movement in the centre.

When rain falls slowly, accompanied by cloudy weather and little sunshine, there is a maximum of saturation and a minimum of evaporation, or in other words, rain falling under such conditions of cloudiness is most effective. On the other hand, if rain falls during continuous sunshine, the loss occasioned by evaporation will be greatest.

In New South Wales there is an enormous loss in run-off, particularly in the Western Division of the State, owing to the duration of the wind storms. These storms, occurring frequently as they do, and lasting for long periods, dry out the soil moisture by stirring the air layers.

If there were no vertical component in the wind, *i.e.*, if the air always moved in lines parallel to the ground surface, there would be no effect from it one way or the other upon evaporation. But wind contributes to the vapour loss of soil moisture, and the moisture of foliage as well, by continually bringing relatively dry air into contact with it directly; and the stronger the wind the more vigorous and effective this action.

Intensity of Duststorms in New South Wales.—This continuous wind movement has resulted in denuding large tracts of the western plains of New South Wales of its surface soil, which blown away as dust, has buried fences and buildings that have intercepted it. Roots of trees, several feet below the natural surface of the ground are often exposed to view. Instances have occurred in New

South Wales during the drought, of dust storms so obscuring the sun at mid-day as to necessitate lamps being lighted indoors to carry on business. The author attaches a photograph of a dust storm that occurred at Narrandera during the drought of 1903.

Influence of Great Dividing Range on Rainfall of New South Wales.—The Great Dividing Range running approximately parallel to the coast line of New South Wales, appears to exercise a very marked influence on the distribution of rain over the State. The rain clouds as they are borne inward from the sea are forced upward into the colder strata of the range and consequently the coastal rainfall is largely in excess of the rainfall west of the Dividing Range. In support of the foregoing assumptions, the author has compiled the tables hereunder from observations of the meteorological staff of the Sydney Observatory. Table "A." gives the mean annual rainfall of a number of stations along the coast of New South Wales, from Milton in the soutn to Tweed Heads in the north. Table " B." shows the mean annual rainfall of stations in the Central Division of New South Wales, extending from Narrandera in the south (Lat. 35° S.) to Boggabilla in the North (Lat. 29° S.) In Table "C." are shown several stations in the Western Division of the State, from Lake Victoria in the south to Thurloo Downs in the north. Perhaps no better illustration could be given than is evidenced by these tables, of the wonderful decrease in rainfall in the three belts of New South Wales, going west from the coast.

Fluctuations in Mean Rainfall.—The experience of recent droughts in Australia shows the very great importance of having a knowledge of the fluctuations and peculiar characteristics of the Australian rivers, especially where the available supply of water is small compared with the

Table "A."—COASTAL DIVISION. Table "B."—CENTRAL DIVISION. Table "C."—WESTERN DIVISION.

Approximate Latitude.	Stations on Coast of New South Wales East of the Dividing Range.	Mean annual rainfall.	Number of years over which observations have extended.	Stations in the Central Division of New South Wales.	Mean annual rainfall.	Number of years over which observations have extended.	Stations in the Western Division of New South Wales.	Mean annual rainfall.	Number of years over which observations have extended.	Approximate Latitude.
29° S.	Tweed Heads ...	67·41	16	Bogabilla ...	21·09	10	Thurloo Downs	9·89	15	29° S.
30° S.	Clarence Heads	57·08	25	Moree	23·38	23	Tibooburra ...	7·81	13	30° S.
30° 30′ S.	Woolgoolga ...	66·11	16	Narrabri	25·92	31	Packsaddle ...	9·31	19	30° 30′ S.
31° 30′ S.	Port Macquarie	63·19	40	Coonabarabran ...	29·57	23	Langawirra ...	8·81	19	31° 30′ S.
33° S.	Port Stephens...	56·80	27	Dubbo	22·54	30	Broken Hill ...	6·65	11	33° S.
34° S.	Sydney	49·68	44	Grenfell	25·78	17	Pooncaira ...	10·08	20	34° S.
34° 30′ S.	Kiama	55·48	17	Temora	19·75	23	Wentworth ...	11·69	35	34° 30′ S.
35° S.	Milton	47·77	18	Narrandera ...	17·61	23	Lake Victoria ...	9·96	21	35° S.

demand. Seeing that the Australian States are embarking on irrigation enterprises, the determination of the volume of water that can be depended upon should be ascertained with precision, so that works of diversion and storage may not be constructed in excess of the water that can be supplied.

Losses in the Artesian Area of Queensland and New South Wales.—Several of the streams within the Murray Basin traverse the artesian area of New South Wales and Queensland, and an enormous quantity of water is absorbed in the porous strata. In the case of artesian basins generally, the water supply is furnished by rain and streams, and enters the pervious beds from above.

According to the authority of Dr. Jack, Government Geologist of Queensland, in a paper read before the Australasian Association for the Advancement of Science, there is a series of soft, grey, very friable sandstone grits and conglomerates at the base of the lower cretaceous formation of Queensland. This sandstone absorbs water with avidity. The rock is moreover so destitute of cement, or it may be that the cement is so soluble, that a lump of it on being saturated with water falls away to a heap of sand. This rock has been named by Mr. Jack the Blythesdale Braystone, and it attains its highest altitude of 1,700 feet above sea level at Forest Vale, on the Maranoa River. The outcrop is crossed by several streams in the Murray Basin, the principal of which are the Maranoa and Warrego Rivers. These streams run only for a small portion of the year, but while they run a rock of the bibulous nature of the Blythesdale Braystone must be absorbing water greedily, and the water must not only spread laterally, but must also fill up as much of the underground portion of the stratum or strata as had been emptied by leakage.

Professor David considers that two kinds of leakage might affect the bibulous beds at the base of the lower

cretaceous formation in a sufficient degree to be worth consideration for the present purpose. Suppose the beds to dip seaward and beneath the sea, and either to rise to the ocean bed or to dip at a lower angle than the slope of the sea bed, there would be a leakage into the sea; and again suppose the outcrops of the beds to occur at gradually lower levels till it attains the sea level, there would be a leakage in the form of springs or into river beds all along the line. In either case the leakage, however compact the beds might be, would not cease till the water-level in the beds was reduced to the level of the sea, unless the head of water were from time to time replenished.

Intake Beds of New South Wales.—In New South Wales a wide belt of very porous sandstone outcrops on the east side of the artesian area. The eastern margin of the intake beds in New South Wales can be traced as far south as the Town of Dubbo, and they form part of the western flanks of the Dividing Range. They dip gently westward, and it is believed that they are continuous under the cretaceous rocks for the whole width at least of the portion of the artesian area which lies in this State. As regards altitude, the intake beds attain an elevation of from 1,200 to 2,250 feet above sea level.[1] Mr. E. F. Pittman, Government Geologist of New South Wales, states[2] that the evidence is conclusive that the Triassic sandstones, and not Blythesdale Braystone, form the storage beds of the New South Wales artesian area. Although there may be local evidence of thinning out of the basal beds of the lower cretaceous against the triassic strata in New South Wales, no distinct evidence has been obtained as to there being any unconformity between the two formations. The Queensland geologists state that they have observed such unconformity

[1] Irrigation Geologically considered by Professor David and Mr. E. F. Pittman, this Journal, Vol. xxxvii., 1903.

[2] River Resources, p. 460.

in parts of their territory, but their descriptions leave it an open question as to how far the phenomena recorded may be due to contemporaneous erosion rather than to unconformity.

Unequal Distribution of Rain.—For the purpose of illustrating the unequal distribution of rainfall over the State of New South Wales, a profile "Appendix B" has been drawn from Sydney to Wilcannia on the Darling River in a generally westerly direction. The various stations and their altitude are shewn along the profile, also the mean rainfall at each station. This diagram shows graphically the increase in rainfall due to difference in altitude. It will be seen that the average rainfall along the sea coast at Sydney, extending over a period of 44 years, is 49·68 inches. Towards the west, Katoomba on the Blue Mountains, at an elevation of 3,330 feet, has a mean annual rainfall of 59·66 inches. Orange, at a distance of 196 miles from Sydney, and an altitude of 2,846 feet, has a mean annual rainfall of 37·5 inches. Going further west there is a fall of 1,850 feet to Wellington and a decrease in rainfall to 23·36 inches, or 14·14 inches below that of Orange. There is generally a gradual decrease in the country westward both with regard to rainfall and altitude. Wilcannia, the most westerly station on the profile, having a rainfall of 10·58 inches while the altitude is 246 feet. The conclusion to be drawn from a study of this profile is that the moisture-laden storm clouds from the Pacific Ocean borne inward are cooled by coming in contact with the mountain range, and precipitate a large portion of their moisture, leaving the interior plain country with a very low rainfall. This would in a great measure account for the humidity of the coast and mountain region, and the drier climate of the Darling.

The author also attaches a map of New South Wales, (*Plate 21*) showing the isoyets of equal rainfall over

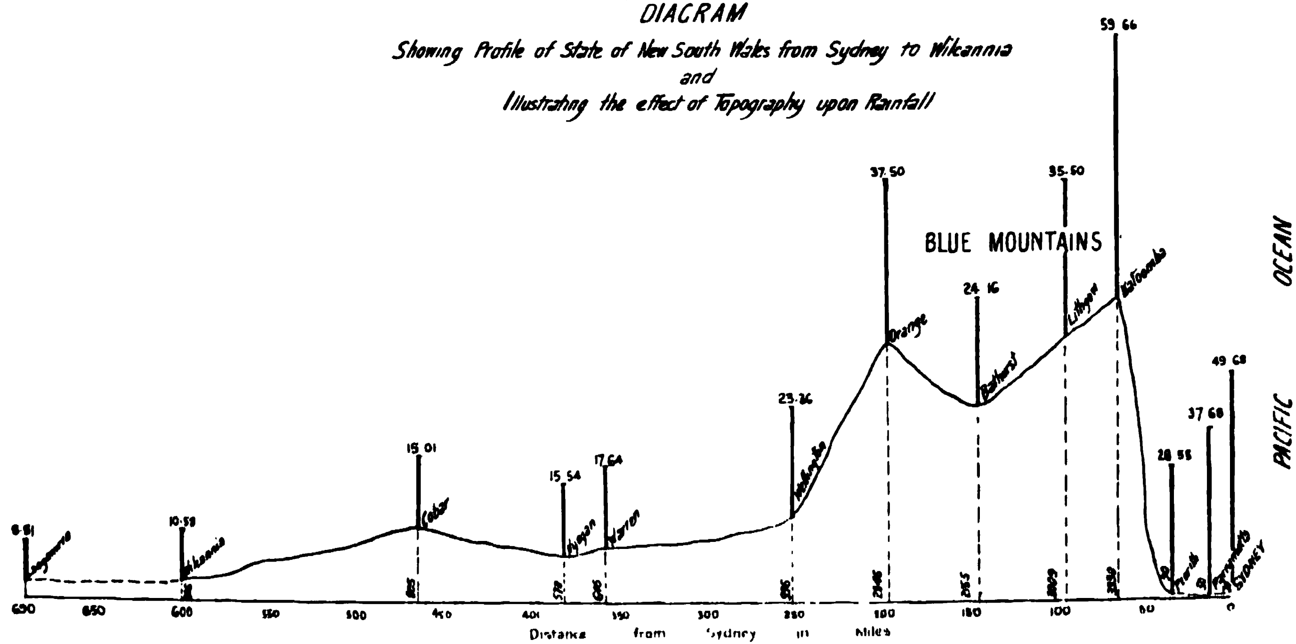
(APPENDIX B)

DIAGRAM

Showing Profile of State of New South Wales from Sydney to Wilcannia

and

Illustrating the effect of Topography upon Rainfall



the State, compiled from the records extending over a number of years, kindly supplied by the Government Meteorologist of New South Wales. From a study of the map it will be observed that in more than half of the State the rainfall is under 20 inches per annum. The increase in rainfall east of the 148th parallel of E. Longitude is of a fairly general character, reaching as high as 70 inches per annum in the extreme north-eastern portion of the State.

Effects of Forests on Rainfall and Run-off.—For some years the question of forest preservation for the purposes of water conservation has engaged the attention of the United States Government, and enormous areas are now under forest reservation, upon which there is a yearly expenditure of about £100,000.

Unfortunately in New South Wales the preservation of forests has not received the attention it deserves, and the pastoralists have denuded enormous areas of forest by ring-barking and felling. In many cases, in addition to the removal of large timber, the edible shrubs and small timber such as boree and myall, useful as feed for stock, have been cut down. In very few instances has any attempt been made to replenish the areas. That the country would re-afforest itself if lightly stocked is evidenced by the fact that within the railway line between Junee and Hay, on the Murrumbidgee Plains, there is considerable growth, which is yearly increasing, of boree and myall trees.

It is an unquestionable fact that forest destruction produces a change in the character of the run-off of a stream, causing a drying up of springs. The trees and undergrowth of a forest not only afford shade for the earth's surface but are important factors in checking the velocity of the wind. The leaves, litter, and other decayed organic matter absorb moisture much more rapidly than soil containing little or no organic matter; consequently the forests in supplying a better absorbing medium

sents the mean rainfall over the whole catchment. This method gives more accurate results than that frequently used of taking the mean of all the records within the total area. The following shews the formula adopted in arriving at the result:—

$V_1\ V_2\ V_3$ etc. = Volumes of rainfall over each partial area in cubic inches.

$R_1\ R_2\ R_3$ etc. = Rainfall in inches over each partial area.

$A_1\ A_2\ A_3$ etc. = Area in square miles over each partial area.

A_w = Area in square miles of whole catchment.

$C = 640 \times 43560 \times 144$ = Co-efficient to reduce to sq. in.

D = Depth in inches of rainfall over whole catchment, then

$$\frac{V_1 + V_2 + V_3 \text{ etc.}}{C\,A_w} = \frac{C\,A_1\,R_1 + C\,A_2\,R_2 + C\,A_3\,R_3 \text{ etc.}}{C\,A_w}$$

$$= \frac{A_1\,R_1}{A_w} + \frac{A_2\,R_2}{A_w} + \frac{A_3\,R_3}{A_w} = D$$

The above formula resolves itself into ascertaining the proportion that each partial area bears to the whole area, and using that proportion as a co-efficient to apply to the mean of all the rainfall records of the observing stations, within each partial area. Thirty-five observing stations were used to determine the mean rainfall, the highest station being at Kiandra with an altitude of 4,640 feet, next in altitude being Nimitybelle, 3,465 feet; Adaminaby, 3,000 feet; Cooma, 2,660 feet; the other stations gradually decreasing in elevation as we go northerly to Gilgal, about 1,200 feet in height. The area of maximum rainfall surrounds Kiandra, which conforms to the accepted theory that rainfall increases with altitude, but the rule is not borne out when we compare Cooma with its elevation of 2,660 feet and Tumut 900 feet, as the following table will show. A peculiar belt of low precipitation surrounds Cooma on the Monaro Plains. It is situated in what might be termed a horse-shoe bend, with mountain ranges to the west, south, and east, which intercept the clouds and rob

them of their moisture before the plains are reached. Large tracts of these tablelands are without timber, and it is more than probable, in view of the experiences of other countries, that this may also have an influence on the low precipitation.

OBSERVING STATIONS TYPICAL OF MAXIMUM, MINIMUM, AND MEAN RAINFALL.

Year.	Maximum Rainfall Station.	Minimum Rainfall Station.	Mean Rainfall Station.	Number of Rainy Days.		
	Kiandra.	Cooma.	Tumut.	Kiandra.	Cooma.	Tumut.
1889	90 06	20·55	38·99	140	81	128
1890	59 09	24·41	37·75	95	126	131
1891	64·89	33 35	37 19	138	103	106
1892	56 99	23 84	32·21	159	114	107
1893	59 42	25 75	33 78	165	127	114
1894	73 06	22·21	40·93	148	120	120
1895	53 61	11·19	26·26	107	85	100
1896	59 04	17 96	25 76	128	87	107
1897	68 32	24·13	27·44	128	77	99
1898	71·14	13·77	24·23	106	88	98
1899	56·98	19 50	28·37	131	92	109
1900	71 73	26·26	37·82	143	97	118
1901	63 88	17 71	26·44	124	72	92
1902	47 41	12 97	16·83	114	63	69
Mean rainfall	63·49	19 73	31·80	121	91	108
No. of years for mean	28	37	16	28	37	16

It may not be out of place to instance some of the vagaries of the season at various observing stations on the catchment during the drought year, 1902:—[1]

ADAMINABY—February 7th (Midsummer)—Remarkably heavy frost, destroyed all potato crops, and even cut up cabbages badly, being the first heavy frost experienced in February during a residence of twenty-five years. June (Midwinter)—Weather very warm, like spring. October—Exceedingly dry the few showers that fell being almost useless for vegetation; this is the first time during an experience of twenty-five years here that good and abundant rains have not fallen during October; 1902 has been the driest year known by residents of over sixty years standing.

[1] Rain and River Observations by H. C. Russell, 1901-2.

CAVAN—February (Summer)—Never saw river so low before. September—Bad spring, all creeks and gullies dry. December—Good rains during this month; 1902 has proved one of the driest years on record here.

HOMELEIGH—March 13th—Terrific hail-storm lasting 45 minutes, hailstones measured $5\frac{1}{4}$ inches in circumference, and remained in places on ground for over two weeks.

QUEANBEYAN—November 12th and 13th.—Continuous red dust storm, lasted upwards of 40 hours.

Stream Gauging.—The most accurate and precise method of determining the run-off of a catchment is by actual gauging of the stream. Observations in connection with the discharge of the Murrumbidgee at Gundagai, extending over a number of years, have been tabulated by the author, and the results shewn in diagrammatic form. Velocity measurements have been made at frequent stages with the latest type of current meter, and in combination with daily gauge readings, a rating table has been compiled showing the discharge for each inch on the gauge. Occasionally the river rose to higher stages than those at which current meter observations were made; the discharges corresponding with these unusually high levels have been deduced, partly by producing the curve of volumes, and partly by applying suitable velocities to the areas of waterway over the banks of the river.

To determine the run-off in inches of the Murrumbidgee catchment at Gundagai from the measured discharges, the following formula has been used:—

I = Depth in inches over catchment.

D = Discharge in cubic feet per annum

then $$\frac{D \times 1728}{8300 \times 640} \times 43560 \times 144 = \frac{D}{19{,}282{,}560{,}000} = I$$

Let D_M = Discharge in millions of cubic feet per annum

Then $$I = \frac{D_M}{19283} = D_M \times {\cdot}00005186$$

S = Second feet per square mile.

$$\text{Then } S = \frac{D_M}{31{\cdot}536 \times 8300} = \frac{D_M}{261748{\cdot}8} = D_M \times {\cdot}00000382$$

Example for Year 1890.

$D = 181{,}462{,}000{,}000$

$D_M = 181{,}462$

Then $I = 181462 \times {\cdot}00005186 = 9{\cdot}41$

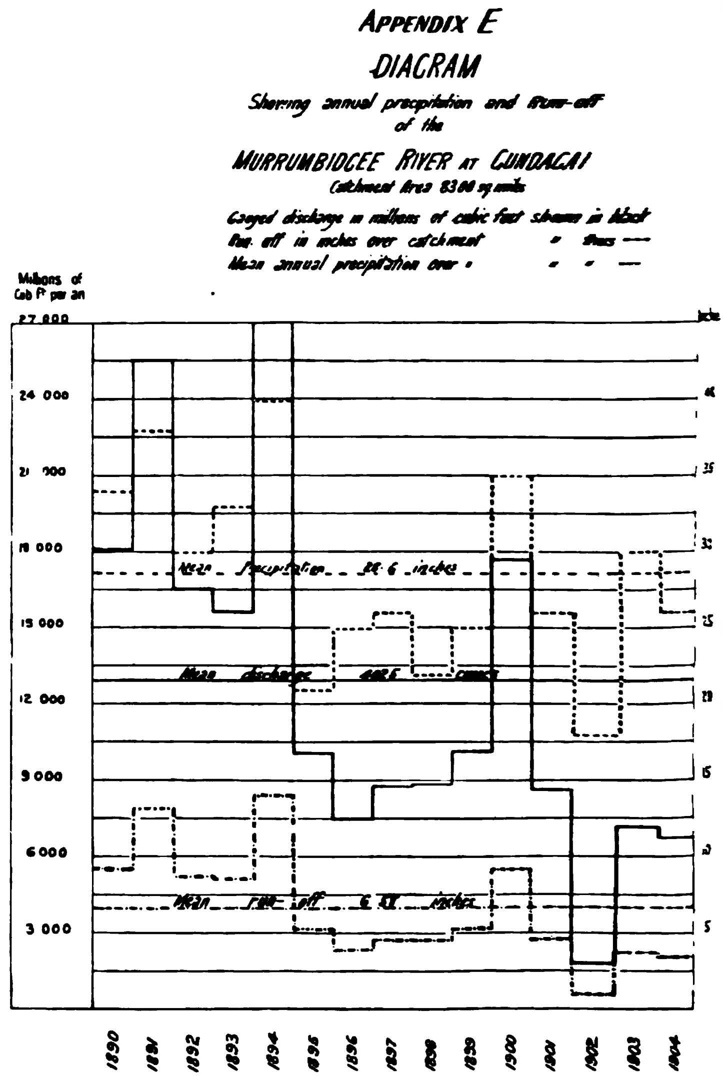
Then $S = D_M\ {\cdot}00000382 = 181462 \times {\cdot}00000382 = 0{\cdot}69$

ANNUAL DISCHARGE, RAINFALL AND RUN-OFF OF MURRUMBIDGEE CATCHMENT AT GUNDAGAI.

Year.	Mean annual rainfall in inches over whole catchment at Gundagai.	Annual discharge at Gundagai in millions of cubic feet.	Annual discharge at Gundagai in acre feet per annum.	Run-off.		Percentage discharged.
				Second feet per square mile	Depth in inches over catchment.	
1890	33·93	181,462	4,165,794	0 69	9 41	28
1891	37 95	256,486	5,888,134	0·98	13 30	35
1892	30·44	165,826	3,806,839	0·63	8·60	29
1893	33·42	156,231	3,586,543	0·60	8·10	25
1894	39·86	270,887	6,218,703	1·03	14 05	35
1895	20·73	101,347	2,326,598	0·39	5·26	25
1896	25·06	74 956	1,720,702	0·29	3·89	15
1897	25·90	87,783	2,015,236	0 34	4·56	17
1898	22·49	88,515	2,032,033	0·34	4·59	21
1899	25·37	100 979	2,318,148	0·39	5·24	21
1900	34·71	177,177	4,078,897	0·68	9·19	26
1901	25·69	86,475	1,985,156	0·33	4·48	17
1902	17·76	17·421	399 929	0·07	0·90	5
1903	29 76	71,667	1,645,304	0·27	3·72	12
1904	25·51	66,708	1,531,392	0 25	3 46	13
Mean	28·6	126,928	2,914,627	0 49	6·58	21·6

The diagram, Appendix "E," has been plotted from the tabulated figures given in the foregoing statement and covers a period of 15 years, viz., from 1890 to 1904. The greatest annual precipitation during this period occurred in 1894, when 39·86 inches of rain was recorded and the run-off reached its highest point, viz., 35% of the rainfall. This run-off, if spread over the catchment area, would represent a depth of 14·05 inches, and the mean rate of flow would be 1·03 second feet per square mile of catchment. The total gauged discharge at Gundagai for the year 1894

amounted to 6,218,703 acre feet, or a mean discharge throughout the year of 8,590 cusecs. The year of least precipitation was 1902 when 17·76 inches of rain fell, and only 5% ran off, representing a depth over the catchment

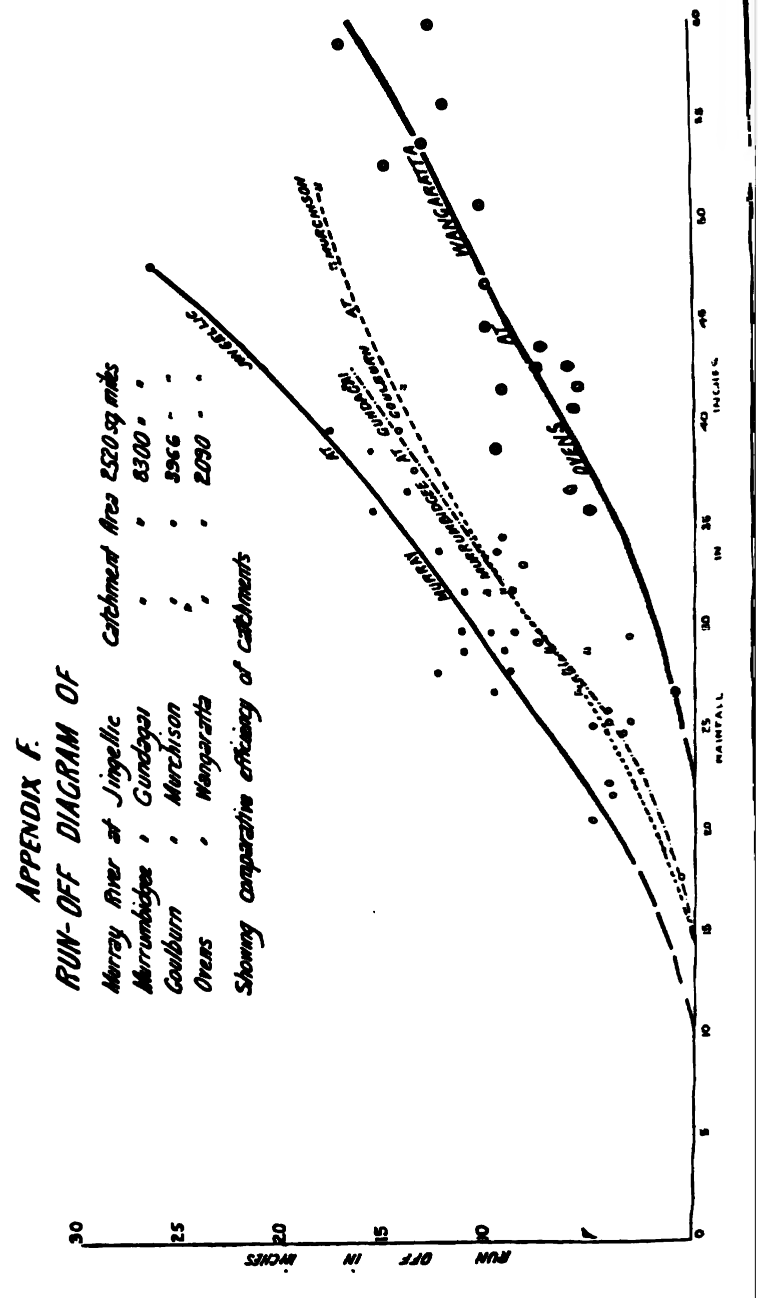


of 0·9 inches, the volume flowing past the gauging station being 399,929 acre feet, or 6·4% of the maximum year 1894.

It may be pointed out that the rainfall for the minimum year was 45% of that recorded during the maximum year, whereas the run-off for the minimum year was only 6·4% of the maximum year. As previously pointed out the winter of 1902 was a very mild one, and instances were given of the hot dry winds during midwinter when snow is usually expected on the ranges. Owing to the comparatively high temperature and wind movement, there was a maximum of evaporation which, combined with small rainfall for the year, would account for the low run-off, and great disparity compared with previous years. The mean precipitation for the whole fifteen years (see diagram, Appendix "E,") was 28·6 inches, and the mean run-off 6·58 inches, or 21·6% of the rainfall, while the mean discharge for the whole period measured 4,025 cusecs.

Comparative effectiveness of Australian Rivers.—With the object of making a comparison of the effectiveness of a few of the Australian rivers, the author has prepared a run-off diagram (Appendix "F") of the Upper Murray River at Jingellic, the Murrumbidgee at Gundagai, the Goulburn at Murchison, and the Ovens at Wangaratta. Curves have been plotted, the abscissæ of which represent the mean annual rainfall in inches over each catchment, and the ordinates, the respective run-off in inches.

The Upper Murray at Jingellic.—The most effective catchment in the Murray Basin is that of the Upper Murray at Jingellic. It is rocky and precipitous, and of a highly impervious character, besides the ground is continually saturated owing to the high rainfall, and its fairly even distribution. At times the melting of the snow on the ranges adjacent to Mount Kosciusko—the highest peak in Australia—considerably augments the river flow. By


APPENDIX F.
RUN-OFF DIAGRAM OF
Murray River at Jingellic Catchment Area 2520 sq miles
Murrumbidgee , Gundagai , , 8300 ,
Goulburn , Murchison , , 3966 ,
Ovens , Wangaratta , , 2090 ,
Showing comparative efficiency of Catchments
MURRAY AT JINGELLIC
MURRUMBIDGEE AT GUNDAGAI
GOULBURN AT MURCHISON
OVENS AT WANGARATTA
RUN OFF IN INCHES
RAINFALL IN INCHES
0
5
10
15
20
25
30
35
40
45
50
55
60

reference to the diagram, it will be noticed that, in regard to the Upper Murray at Jingellic, there is no considerable variation of the curved line from the observations, and by producing the curve to the base line, it shows that run-off would take place with an annual rainfall of 10 inches if it were evenly distributed throughout the year. The drought year of 1902 was responsible for the lowest run-off, viz., 20%, whereas the next lowest was 31% in 1896. During the year 1894, the mean rainfall on the drainage area amounted to 48 inches, and the proportion of rainfall discharged was no less than 55%.

The Goulburn River, the principal Victorian tributary of the Murray River, rises in the Dividing Range where the summits reach an elevation of 5,000 feet. The drainage area above the Murchison gauging station is 3,966 square miles, a considerable portion of which is rocky and precipitous. By referring to the diagram it will be seen that a large proportion of the rainfall is discharged. The catchments of the Goulburn River at Murchison, and the Murrumbidgee River at Gundagai, seem to bear a strong resemblance in point of effectiveness, with the exception that when the rainfall exceeds 40 inches, the Murrumbidgee has a higher percentage of run-off.

The Ovens at Wangaratta, which has a drainage area of 2,090 square miles, and an annual rainfall of about 40 inches is the least effective river of the series. The observations from which this information has been compiled extend over a period of 15 years. Although the gathering grounds of the upper reaches of the four rivers are somewhat similar in character, the diagram shows the futility of endeavouring to arrive at a general formula that would be equally applicable for the determination of rainfall to run-off for all catchments. For instance, with an annual rainfall on the catchment of the Upper Murray at Jingellic of 47 inches,

the run-off represents 26 inches, whereas with a similar rainfall on the catchment of the Ovens River at Wangaratta, the run-off represents 10 inches.

Monthly Run-off and Rainfall over Murrumbidgee Catchment at Gundagai for the Years 1900 - 1904.—For the purposes of showing the difficulty in arriving at any definite conclusion as to the relation between monthly rainfall and monthly run-off, over any extensive gathering ground, the author has compiled the following table and diagram—Appendix "G"—for the years 1900 – 1904. As previously referred to in this paper, the source of the Murrumbidgee is many miles away from the gauging site at Gundagai, and as the catchment is a very extensive one, the effect of precipitation on the mountains is not felt at the gauging station until some weeks later. It is apparent that when estimates of run-off are prepared for such a large area, the period for the computations should extend over several years. By reference to the table, it shows that a higher percentage of rainfall is discharged during the months from June to November, when the grounds have become saturated after the winter rains and evaporation is at a minimum. A peculiar circumstance occurs in regard to the table for the month of October, 1900, wherein the measured discharge at Gundagai amounted to 297%, or approximately three times the precipitation for that month, over the whole of the gathering grounds. This remarkable phenomenon is undoubtedly due to the abundant rains during the previous four months which completely saturated the soil, and the flow of ground water was maintained long after the cessation of rain over the catchment. There are also numerous instances in this table which amply demonstrate that an interval of two weeks or even more may elapse between the precipitation and its flow past the gauging station at Gundagai.

APPENDIX G

MONTHLY PRECIPITATION & RUN-OFF

OF THE

Murrumbidgee River at Gundagai

Monthly precipitation shown in black ———

" Run-off " thus - - - -

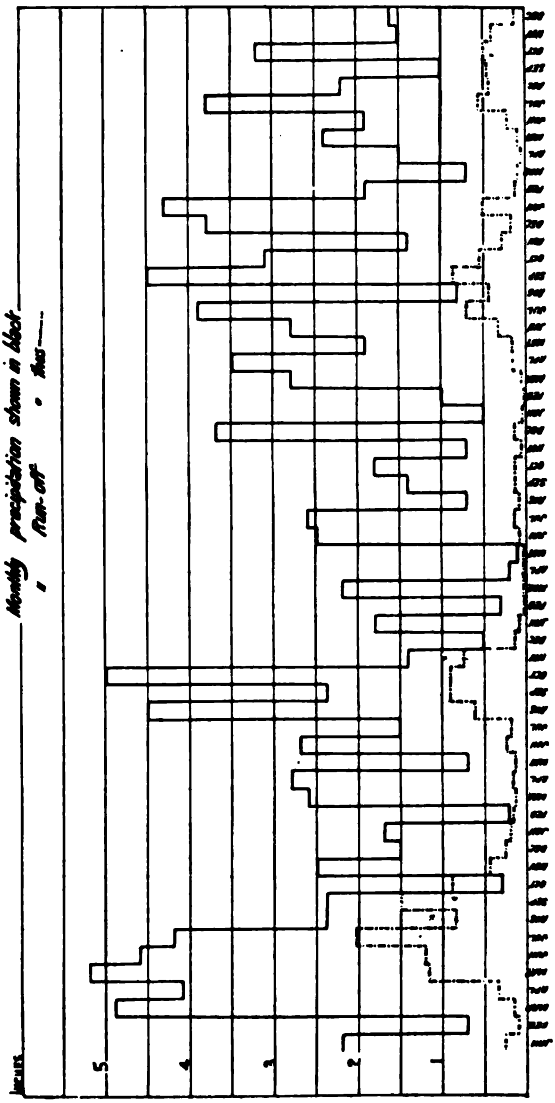


TABLE.

Month.	1900 Mean discharge in cusecs at Gundagai.	1900 Run-off in inches.	1900 Rainfall in inches.	1900 Percentage discharged.	1901 Mean discharge in cusecs at Gundagai.	1901 Run-off in inches.	1901 Rainfall in inches.	1901 Percentage discharged.
Jany.	1825	0·25	2·2	11	1374	0·19	1·7	11
Feby.	759	0·10	0·7	14	1341	0·17	0·2	85
March	1172	0·16	4·9	3	922	0·13	2·6	5
April	2552	0·34	4·1	8	1173	0·16	2·8	6
May	8387	1·17	5·2	22	977	0·14	0·7	20
June	8974	1·20	4·6	26	1735	0·23	2·7	9
July	14754	2·05	4·2	49	1292	0·18	1·5	12
Aug.	6105	0·85	2·4	35	4466	0·62	4·5	14
Sept.	11208	1·50	2·4	62	6687	0·90	2·4	37
Oct.	6384	0·89	0·3	297	6543	0·91	6·0	15
Nov.	3361	0·45	2·5	18	5426	0·73	1·4	52
Dec.	1771	0·25	1·5	17	961	0·13	0·5	26
		1902				**1903**		
Jany.	605	0·08	1·8	5	236	0·03	0·5	6
Feby.	187	0·02	0·3	7	96	0·01	1·0	1
March	171	0·02	2·2	1	386	0·05	2·8	2
April	221	0·03	0·2	15	1179	0·16	3·5	5
May	190	0·03	0·1	30	1210	0·17	1·9	9
June	624	0·08	2·5	3	2378	0·32	2·8	12
July	1023	0·14	2·6	6	5055	0·70	3·9	7
Aug.	543	0·08	0·7	11	3056	0·42	0·8	18
Sept.	861	0·12	1·4	8	6460	0·87	4·5	19
Oct.	810	0·11	1·8	6	3894	0·54	3·1	17
Nov.	408	0·05	0·7	7	2034	0·27	1·4	19
Dec.	947	0·13	3·7	4	1171	0·16	3·8	4
		1904						
Jany.	3577	0·50	4·3	12				
Feby.	866	0·11	1·9	6				
March	630	0·09	0·7	13				
April	476	0·06	1·5	4				
May	658	0·09	2·4	4				
June	1458	0·20	1·9	10				
July	4022	0·56	3·8	15				
Aug.	3001	0·42	2·2	19				
Sept.	3282	0·44	1·0	44				
Oct.	3529	0·49	3·2	16				
Nov.	2902	0·39	1·5	26				
Dec.	822	0·11	1·6	7				

The following formula has been used by the author in preparing the preceding table, shewing the relation existing between the monthly rainfall and run-off :—

D = Depth in inches over catchment.

Q = Mean monthly discharge as gauged in cusecs.

A = Area of catchment in square miles.
N = Number of days in month.

$$\text{Then } D = \frac{Q \times N \times 86400 \times 1728}{A \times 640 \times 43560 \times 144} = Q\frac{C}{A}$$

$\frac{C}{A} = {\cdot}000139$ when $N = 31$ days.
$\frac{C}{A} = {\cdot}000134$ when $N = 30$ days.
$\frac{C}{A} = {\cdot}000129$ when $N = 29$ days.
$\frac{C}{A} = {\cdot}000125$ when $N = 28$ days.

Example for January, 1900.

Q = 1825 cusecs.
A = 8300 square miles.
N = 31 days.
$\frac{C}{A} = {\cdot}000139$

$$D = \frac{Q \times C}{A} = 1825 \times {\cdot}000139 = {\cdot}25 \text{ run-off inches.}$$

Darling River at Wilcannia.—The River Darling is certainly unique both with regard to fluctuation of flow and low run-off. Its source is in the Dividing Range in Queensland, and it forms the main line of drainage of the southern part of Queensland and western part of New South Wales. The tributaries of this river extend far into Queensland, and although of an intermittent character they feed the main stream with immense volumes in times of tropical rainfall. The New South Wales tributaries of the Darling rise in the Great Dividing Range, from which they flow westward through great alluvial plains which slope almost imperceptibly. The gathering grounds of the Darling embrace the immense area of about 235,000 square miles, of which 104,000 square miles are in the State of Queensland.

Large non-contributing area.—The greater portion of the Darling Basin is so flat that it rarely contributes to the

flow of the main river, and the bulk of rain that falls on the catchment is either lost by evaporation or in the underground porous strata. Mr. H. C. Russell, late Government Astronomer,[1] however, states that:—

"This view may be pressed somewhat too far, and will have to be modified to admit that in heavy rains water does reach the Darling from it. On the 21st January, 1885, a remarkable rain-storm entered this colony in the north-west, not far from Milparinka, and travelled at the rate of about seven miles per hour, straight across country to the sea in an E.S.E. direction. On all the country round Wilcannia from 10 to 11 inches of rain fell in about 40 hours. The river had been very low for months before, but sufficient water from this rain-storm ran off the comparatively flat country to make a flood in the Darling at Wilcannia, which reached a maximum height of 28 feet above summer level. This flood did not subside to the old level until February 26th, which was clear proof that the rain water not only filled the river, but continued to drain into it for several weeks. Certainly the water did not come past Bourke, which, being in the margin of the storm, was but little affected by it; and the river measures there showed that the only rise reached its maximum of 4 feet, and was all over in four days. There was no other possible way for it to come, but off the country about Wilcannia, where the rain-storm passed over."

Plain Country contributes during periods of sudden rain. The instance given shows that the plain country of the Darling, although regarded as a non-effective area, does contribute during periods of sudden and heavy rain. Although the Darling watershed is sparsely populated, the pastoralists take great interest in forwarding returns of the rainfall to the Government Meteorologist, and there are a sufficient number of rain gauges to show with a reasonable degree of accuracy what the rainfall is. Through

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[1] "Source of Underground Water in Western Districts. This Journal, XXIII., 1889.

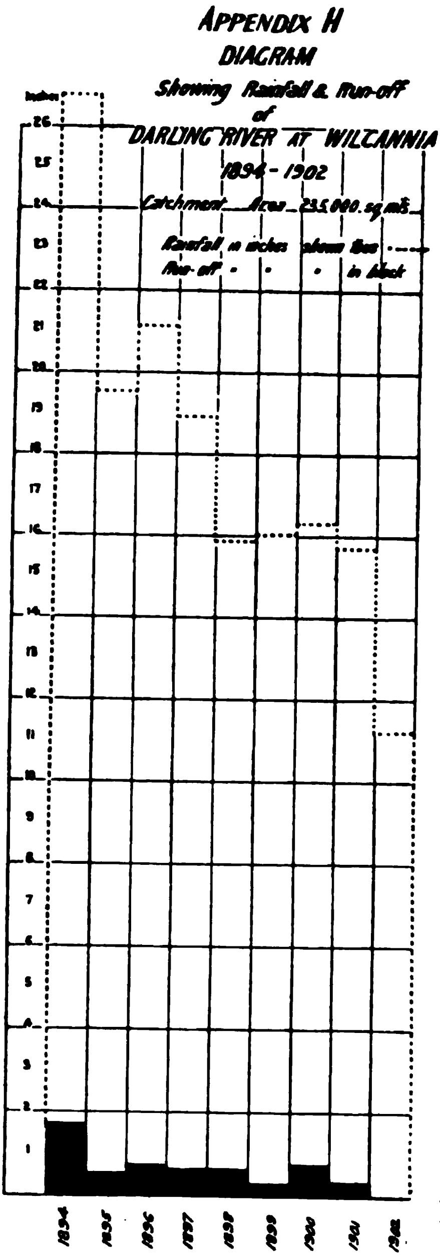
the courtesy of the Government Meteorologists of New South Wales and Queensland, the author has been supplied with the rainfall returns extending over a number of years and he has compiled these records from which the mean annual rainfall has been determined.

To investigate the question of run-off over the entire Darling catchment would have been futile, as the lowest gauging station at which reliable stream measurements have been taken is at Wilcannia, about 500 miles from the point where the river joins the Murray. Wilcannia has, therefore, been selected as the station from which deductions of rainfall and run-off have been made.

Stream Measurement of the Darling River at Wilcannia. The method adopted for measuring the discharge of the Darling at Wilcannia was that known as rod floats. The range of observations was very extensive, and covered all stages of the river from summer level to moderate floods. Complete sections of the waterway were taken, and rod velocity measurements made at frequent intervals. Daily gauge readings have been recorded at Wilcannia for many years, and by combining these with the measured discharge, a rating table was prepared showing the discharge for every inch on the gauge. On this basis the total monthly discharges werc estimated. It is not claimed that the results are as correct as they would have been if the more modern and refined method of current meter observations had been practised, but for the purpose of this paper they may be taken as well within the bounds of reasonable accuracy.

Subdivision of Catchment.—The catchment area above Wilcannia has been divided into districts—(*a*) The Murray Basin within the State of Queensland. (*b*) New South Wales catchment above Bourke. (*c*) Area between Bourke and Wilcannia.

As previously mentioned, the records of the Queensland rainfall stations have been used in computing the mean



rainfall over the area within that State, the station showing the greatest rainfall being Toowoomba on the north-eastern fringe of the catchment. With regard to the portion lying between the northern boundary of New South Wales and the town of Bourke on the Darling River, the rainfall has been based on the mean of 485 recording stations. The rainfall on the balance of the catchment lying between Bourke and Wilcannia has been compiled by the author from the observations of a large number of stations supplied by the Meteorological Department of this State. The formula adopted in computing the mean precipitation over the whole of the gathering grounds, is identical with that adopted in

connection with the investigations respecting rainfall and run-off of the Murrumbidgee catchment at Gundagai. The diagram (Appendix "H") and following table shows the result of the calculations for the years 1894 to 1902 inclusive, which period covers a high year and the lowest year on record.

TABLE OF RAINFALL AND RUN-OFF OF THE DARLING RIVER AT WILCANNIA. Catchment area 235,000 square miles.

Year.	Annual discharge of the Darling at Wilcannia in millions of cubic feet.	Mean discharge in cusecs.	Second feet per square mile	Mean rainfall in inches over catchment.	Run-off in inches over catchment.	Percentage discharged.
1894	253,644	8,043	0·034	26·81	0·464	1·73
1895	60,234	1,910	0·008	19·53	0·110	0·56
1896	87,733	2,782	0·012	21·14	0·161	0·76
1897	70,199	2,226	0·009	18·94	0·128	0·67
1898	57,049	1,809	0·008	15·87	0·104	0·66
1899	27,783	881	0·004	16·04	0·051	0·31
1900	69,474	2,203	0·009	16·33	0·127	0·77
1901	32,167	1,020	0·004	15·71	0·059	0·37
1902	710	22	0·0001	11·22	0·001	0·01

Effect of abnormal drought of 1902.—From the above figures it will be seen that during the year 1894 the mean rainfall was 26·81 inches, of which only 1·73% was discharged or 0·034 second feet per square mile. The great drought culminating in the year 1902 was unparalleled in the history of Australian hydrology, and was responsible for the Darling River becoming a mere chain of water-holes. The rainfall over the Darling catchment for that year amounted to 11·22 inches, of which 99·99% was entirely lost by evaporation and other causes. When one realises the vast extent of the gathering ground of the Darling River at Wilcannia, an area one and a quarter times the size of France, it is difficult to imagine so small a run-off. If half the rain that fell during 1902 reached the river channel, and passed the Wilcannia gauging station, it would have resulted in a mean discharge throughout the year of 97,120 cusecs, or 4,415 times the amount actually discharged.

The author has previously alluded to the enormous quantities of water discharged by the Darling after cyclonic disturbances, and he regrets that, owing to complete rainfall data not being readily obtainable, he was unable to show the proportion of rainfall discharged during the flood year of 1890, when the flow of the Darling was 50% greater than that of the flow of the Murray below the confluence of the Murrumbidgee.

"In the great flood of 1890, owing to tropical rains, the Darling resembled an inland sea, the spread of the water being 60 miles wide. Instances were given during this period of steamers discharging cargo 25 miles back from the river channel. The discharge of the Darling at Wilcannia for the year 1890 reached the enormous volume of 717,000,000,000 cubic feet."—The Murray River, Irrigation and Navigation, by Robert T. McKay, Sydney University Engineering Society, 1903.

Behaviour of Proposed Reservoir at Barren Jack, on the Murrumbidgee River.—The utilisation of the waters of the Murrumbidgee River for the purposes of irrigation has engaged the attention of various Governments of this State for the past ten years, and at last the proposal has taken definite shape. Owing to the low rainfall on the gathering grounds during the summer months—the months when irrigation is most needed—the flow of the Murrumbidgee River is not sustained, and provision is therefore necessary to impound the flood waters for distribution on the plain country. Surveys show that an excellent site for a dam exists at a place known as Barren Jack Mountain, a few miles below the confluence of the Murrumbidgee and Goodradigbee Rivers. The river at this spot passes through a narrow gorge several hundred feet in height, with granite outcrop in the bed of the river and mountain sides. The catchment area is 5,000 square miles, and contour surveys shew that a reservoir, if constructed to a height of 200 feet,

would impound 33,381,000,000 cubic feet, or 766,320 acre feet. The calculations show the behaviour of a reservoir proposed to be formed by building a dam across the Murrumbidgee River at the site mentioned. It may be considered of interest in its bearing upon the subject matter of this paper as an example of the fluctuations of an impounding reservoir fed by an Australian river, and drawn upon for the purpose of irrigation during a period of unprecedented drought.

Acting under the instructions of the Chief Engineer for Water Supply, the author has been charged with investigations in order to prove on available data how the proposed reservoir would have behaved in supplying water for irrigation on the Riverina Plains some 300 miles below the site of the reservoir, and in providing a minimum volume for the use of lower riparian holders between the town of Narrandera and the junction of the Murray and Murrumbidgee Rivers. In the investigation the irrigation requirements of one canal on the north, and one canal on the south side of the Murrumbidgee have been provided for, also provision for riparian flow to pass below the offtake.

From the information so far obtained, it has been calculated that after commencing in January, 1900, with an impounded volume of 766,320 acre feet, the reservoir would have been drawn upon continuously owing to the dry summer and reduced at the end of March to 614,120 acre feet. The high river of the succeeding months would have rapidly filled the reservoir, overflowed it in July, and kept it so until the end of December of that year. The low rainfall of the 1901 summer would have caused the reservoir to be drawn upon to a considerable extent, decreasing the depth of water by 23 feet, representing a hold over volume of 506,408 acre feet. The winter rains would have replenished the reservoir, filled it to overflowing in September, and retained it

in that condition till the end of November, the beginning of the abnormally dry period which extended to April 1903. The severe tax on the storage capacity would have rendered it necessary during the height of the drought to reduce the irrigation supply and limit the riparian flow to 400 cusecs. The reservoir would have proved capable of meeting the requirements, but nevertheless would have been almost empty in March 1903. From that date onward it would have gradually refilled, and overflowed in January 1904. The full irrigation and riparian supplies would have been provided from June, 1903, until the end of the five years period of the investigation, viz., December 1904. The water level in May 1904 would have receded to 168 feet, or 32 feet below top water level, but in September of that year it would have refilled and overflowed.

The Murray River at Morgan.—The town of Morgan, situated at about 200 miles from the point where the Murray River enters the Pacific Ocean, is the lowest station on the river at which discharge measurements have been taken. The Murray at Morgan drains an immense territory, the catchment area being no less than 408,000 square miles. Seeing that no previous investigation has been made to determine the relation of rainfall to run-off, over this catchment area, the author has collated all information relating to the matter in order to arrive at certain definite conclusions. He has compiled the rainfall records of the various State Observatories, and divided the whole area into sub-areas, comprising:—

(1) The Darling River catchment at Wilcannia.
(2) The Darling catchment south of Wilcannia to the junction of the Murray River at Wentworth.
(3) The catchment of the Murray River above Mildura.
(4) The Murray basin in Victoria below Mildura.
(5) The Murray basin in South Australia above Morgan.

The same method of computation has been used in this case, as in the investigations respecting the relation of rainfall to run-off, of the Murrumbidgee and Darling catchments, referred to in this paper. The catchment comprises many remarkable topographical and geological features, and has a wide range of climatic conditions and rainfall. The maximum rainfall records reach as high as 80 inches per annum at Kiandra on the Great Dividing Range, but as there are no gauges on the highest peaks of the range above Kiandra, it would no doubt be found that, in the vicinity of Mount Kosciusko, the records would reach 100 inches per annum. In the south-western portion of the catchment, within the State of South Australia, the rainfall during abnormal drought falls as low as two inches per annum. With regard to the Victorian tributaries, there is a high precipitation on the gathering grounds of the Indi, Mitta Mitta, Kiewa and Goulburn Rivers, and as the watersheds are of an impervious character, the percentage discharged is correspondingly large. The Ovens River has a moderate run-off; on the other hand, the run-off of the Campaspe and Loddon Rivers is very small indeed, while the Avoca rarely, and the Wimmera never, make any contribution to the main stream.

The run-off of the Murray River at Morgan has been ascertained from discharge observations carried out by the South Australian Water Supply Department, and current meter velocity measurements have been used. From the tabulated statement and diagram attached to this paper, (Appendix "K") it will be seen that in the period under review, the average rainfall over the whole of the Murray Basin at Morgan is 15·56 inches, or in other words, if the whole quantity of water falling on this area were equally distributed over the surface, instead of the bulk of the rain

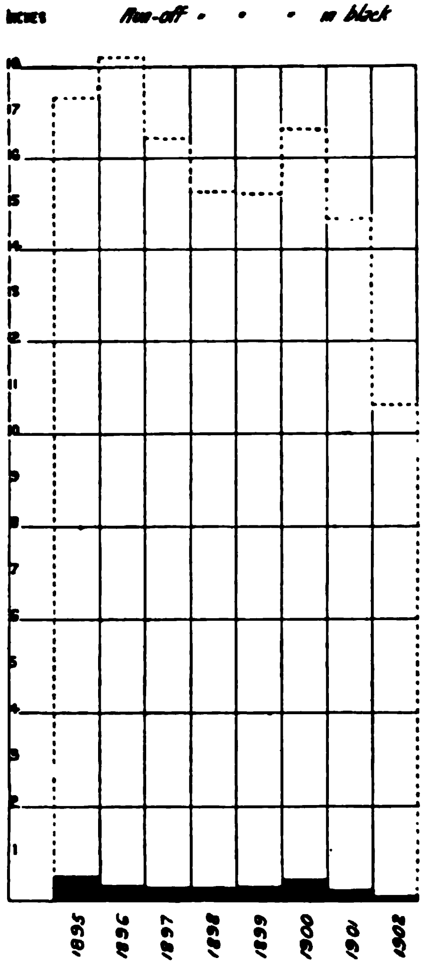
APPENDIX K

DIAGRAM

Showing Rainfall and Run-off
of

MURRAY RIVER AT MORGAN
1895-1902
Catchment Area 408 000 sq. mls

Rainfall in inches shewn thus......
Run-off " " " in black



falling on the eastern portion, and very little on the western area, it would represent a sheet of water 15·62 inches deep. The maximum rainfall recorded over the whole catchment for the period under investigation was 18·21 ins. in 1896, the run-off in inches being 0·32 or 1·75%. It may be pointed out that although the rainfall for 1895 was nearly 1 inch less than that recorded in 1896, the run-off was greater, viz., 0·54 inches, while the discharge represented 3·12%. The year 1894 was a wet one, the volume passing Morgan gauging station amounting to 955,087,000,000 cubic feet, or nearly double that discharged during 1895. The thorough saturation of the ground during 1894 accounted in a great measure for the

percentage of run-off in 1895 being high, compared with other years of this investigation. In common with the other rivers of the Commonwealth, the Murray in 1902 reached the lowest discharge ever recorded, the volume at Morgan for the year amounting to 93,274,000,000 cubic feet, or about 9% of that discharged during the flood year of 1890. The rainfall over the whole gathering grounds during 1902 amounted to 10·64 inches, the run-off being 0·10 inch, representing the insignificant discharge of 0·94%. The loss during the year, therefore, amounted to 99·06% of the rain that fell on the catchment.

TABLE SHOWING RAINFALL AND RUN-OFF OF MURRAY RIVER AT MORGAN. Catchment area 408,000 square miles.

Year.	Annual discharge in millions of cubic feet.	Annual discharge in acre feet.	Mean annual discharge in second feet.	Run-off: In second feet per sq. mile.	Run-off: In inches over catchment	Rainfall in inches over catchment	Percentage discharged
1895	509,951	11,706,945	16,170	0·039	0·54	17·35	3·12
1896	297,939	6,839,786	9,448	0·023	0·32	18·21	1·75
1897	277,548	6,371,669	8,801	0·022	0·29	16·46	1·76
1898	281,787	6,468.984	8,935	0·022	0·30	15·28	1·96
1899	274,619	6,304,428	8,708	0·021	0·29	15·23	1·90
1900	424,271	9,739,989	13,454	0·033	0·45	16·64	2·70
1901	242,321	5,562,963	7,684	0·019	0·26	14·68	1·77
1902	93,274	2,141,291	2,958	0·007	0·10	10·64	0·94
Means	300,214	6,892,007	9,519	0·023	0·32	15·56	2·00

When it is considered that the Murray drains such an enormous tract of country, extending far into four States of the Australian Commonwealth, and that it receives such tributaries as the Murrumbidgee, Darling, Mitta Mitta, Kiewa, Ovens, Goulburn, Campaspe and Loddon, it should be one of the greatest streams in the world. Owing to the enormous extent of non-effective area, and the peculiar character of the catchment, the run-off is extremely disappointing. There is, however, a volume of water available, sufficient to reclaim, with proper storage, large areas of lands within the States of Queensland, New South Wales, Victoria, and South Australia.

The preceding figures cover the minimum flow, and the longest period of minimum flow and continuous drought in the history of Australia. Although there may be a recurrence of such years, a study of the meteorological records of Australia leads one to the conclusion that there will be a return of good seasons, and consequently much higher river discharges than have occurred during the period of this investigation.

A large amount of official data has been placed at my disposal in connection with the preparation of this paper, and I have to thank Mr. Wade, Chief Engineer for Water Supply, for his courtesy in permitting the data to be used. To Mr. French of the Water Supply Department, I am indebted for assistance in the calculations.

IRRIGATION WORK IN CALIFORNIA, AND ITS RELATION TO THE TRANSMISSION OF ELECTRICITY.

By T. ROOKE, Assoc. M. Inst. C.E.

[Read before the Engineering Section of the Royal Society of N. S. Wales, 17th October, 1906.]

THE subject on which I have the honour to address you to-night is perhaps one on which, an engineer, whose work is principally connected with electricity, might not be expected to speak; a short explanation is, therefore, necessary. Nearly four years ago when travelling through California on my way to Australia, particular attention was paid to long distance electric transmission work, and it was observed that electricity was being used to pump water for irrigation purposes. On reaching Australia it

was found that much interest was taken in irrigation questions, and this immediately suggested the proposition that electricity, if produced cheaply enough, might possibly be applied to the irrigation of the land in the same manner as it was applied in California. I had the honour to draw attention to this subject in a short memoir presented to the Engineering Section of this Society in July, 1903, and then determined, that if opportunity offered, would visit California again, and study this question more closely. It was necessary in the meantime to study the problem of producing cheap electricity, for up to 1904 the general public, at all events in Sydney, could not purchase electricity for less than 3d. a unit, although supply companies had been in operation for ten years or more. At 3d. a unit, transmission and irrigation were entirely out of the question as a commercial possibility. I may also offer, as some excuse for approaching this subject, the fact of having been brought up and lived amongst people who were and are connected principally with farming matters.

The particular aspect of the question to which it is proposed to draw attention this evening, is the aspect which is presented by a study of the conditions in California. There, the country was to a great extent arid until irrigation was carried out, and, by its success, demonstrated the existence of great agricultural possibilities, not only for the large capitalist capable of taking up large tracts, but for the settler with next to no capital, except his health and strength. In California much irrigation work is being carried out by means of water pumped from below the surface, and much of this water is pumped by electricity transmitted from the ranges of the Sierra Nevada. A similar method of irrigating may be possible in Australia; whether it will be so or not depends on a number of

circumstances, which may be referred to, but cannot be fully dealt with, in the scope of this paper.

It is intended, therefore, first of all to give an account of the irrigation works seen in California, more particularly those operated from electric transmission lines, and then to consider some of the possibilities in connection with such work in Australia. On reaching New York last March, I got into touch with the General Electric Company, and the Westinghouse Company, who kindly furnished letters of introduction to their agents in California. On reaching California, these gentlemen made the necessary arrangements for visiting the irrigation works in the San Gabriel Valley, the San Joaquin Valley, and in the neighbourhood of Bakersfield. Several days were spent driving through the country districts in order to see these irrigation works, and to photograph pumping stations operated electrically, as it was felt that such photographs would be the strongest testimony possible to obtain.

Pomona was the first township visited, and an hour or so was spent examining the deep well pumps made by Messrs. Addison, which are ingenious and simple. There are two concentric pump rods operated from 2 cranks placed at 180° apart. On the end of each pump rod is a bucket provided with clack valves arranged as a cone. As the crank shaft turns, the two buckets alternately approach and recede from one another, and by so doing raise water. The buckets are easily lifted out of the well and replaced. The pump barrel is a stout tube some 10 inches in diameter, and fits closely into the well casing. It really forms the last length of a casing inside, and concentric to the well casing. It is readily raised or lowered for examination and repairs. This was the only form of deep well pump seen in use, and it was seen in all the pump-houses in the

San Gabriel and San Joaquin Valleys. It is understood, however, that in some of the wells compressed air is used for raising water, and although the efficiency of the system is variable from 23–60%, it has advantages in respect of simplicity, and is not deranged by the presence of grit in the water. In applying this system the well casing is sunk to the water-bearing stratum in the usual manner, and an air pipe is lowered down the casing until it is submerged sufficiently to throw up water. The actual submergence and the sizes of the air pipe and the air nozzle, are matters of nice adjustment in order to obtain the best results. A well from which water was drawn by this system, was seen in operation, but the water raised was not being used for irrigating.

At Pomona a rig or buggy was obtained and a drive taken through the orange orchards in the neighbourhood. A number of pumping stations were visited. The first of these was just outside Pomona. The pump-house is a light wooden structure, cheap to a degree. It contains a 20 h.p. 3 phase motor, operating at 440 volts, 50 cycles, and driving a 10 in. × 24 in. Addison deep well pump, capable of lifting 320 gallons per minute. The well was about 200 feet deep, the depth to the water 110 feet; the motor is connected by a belt which has an advantage over a direct drive, in being to some extent a safety device in the event of any obstruction entering the pump. Electricity was supplied to the motor by a 10,000 volt overhead 3 phase transmission line forming part of the system owned by the Edison Company of Los Angeles. This company uses water power to generate electricity in several power houses built in the cañyons, opening into the valley. From these, electricity is transmitted at 33,000 volts, over a distance of some 88 miles to Los Angeles. At Pomona, which is on the route of the transmission line, and some 60

miles from the power houses, there is a sub-station from which electricity is distributed at 10,000 volts to the neighbouring irrigating plants.

The switchgear in the pump house consisted of a 3 phase meter, 3 pole switch, plug sockets for connection of standard meter and 3 pole fuse. The 440 volt current is supplied from transformers sometimes placed in a little tin shed, and sometimes on poles outside the pump house. Into this shed the 10,000 volt line wires are led, and three single pole switches, known as ram horn switches, are provided, by means of which the transformers may be disconnected from the line wire. A multiple gap lighting arrestor is also provided. The cost of rough labour is 6/- a day. The wages of a pump attendant is £12 a month, and one man attends to several stations, the number depending on the distance between them.

In this district water for irrigating is obtained from a sandy sub-stratum, into which the supply enters through an outcrop of limited area at the foot of the mountain ranges. The last few years have been exceptionally dry, and the author was told that the level of the water in this stratum has gradually been lowered, a matter which causes some anxiety, and points to the necessity of restricting the number of wells or the quantity of water pumped, in such a manner as to prevent exhaustion of the supply.

From Pomona, we drove east to Ontario, passing a number of pumping stations all operated electrically. The water raised by the first pumping station was used to irrigate a crop of lucerne, the water raised at the other stations visited, appeared to be used principally to irrigate orange orchards. Concrete pipes laid underground distribute the water from the pumping stations. At suitable distances along these pipes, vertical branches project above the ground sufficiently to prevent the water

from running over their tops. Some 8 inches below the top of each branch, holes are made and each hole is provided with a tin slide, so that it can be opened or closed at will, and the quantity of water put on the land regulated. Usually one of these branches is provided to each row of orange trees. A special harrow is used to cut furrows, along which water is conducted down each row. In some orchards a trench only is used, and wooden stops bank up and divert the water on to the land.

The journey was continued to Ontario, and a visit paid to a sub-station erected there, from which electricity is distributed for pumping in the same manner as it is distributed from the Pomona sub-station. The engineer in charge furnished some interesting information. Motors are hired to customers at the following monthly rentals:—

$\frac{1}{16}$ hp.	4s.	3 hp.	15s.
$\frac{1}{10}$ hp.	4s.	5 hp.	21s.
$\frac{1}{4}$ hp.	5s.	$7\frac{1}{2}$ hp.	28s.
$\frac{1}{2}$ hp.	5s.	10 hp.	30s.
1 hp.	10s.	15 hp.	40s.
2 hp.	12s.	20 hp.	80s.

The price at which electricity is supplied to motors ranges from $4\frac{1}{2}$d. to $1\frac{1}{4}$d., according to the quantity used, and is subject to a further 10% if the account is paid before the 10th of the month on which it becomes due. In the same district, gasolene engines were used before the advent of electricity and are used to a small extent now, although none were inspected. It is understood that they have mostly been displaced by electricity. Gasolene distillate is hauled 8 miles and delivered at $2\frac{1}{2}$d. a gallon. Gasolene in 5 gallon cans costs $9\frac{1}{2}$d. a gallon. These prices are per U.S. gallon, which is approximately 5/6 British gallon.

Data were also furnished concerning the cost of pole line construction for distributing electricity to the pumping

stations. A 10,000 volt line suitable for the transmission of 100 hp., costs £154 per mile, the rates paid for labour and materials being as follows:—

30 ft. poles 8 inch tops	...	19/4	each
35 ft. „ 7 „ „	...	23/6	each
40 ft. „ 6 „ „	...	24/7	each
Linesman's Wages ...	...	11/–	a day
„ Mate ...	...	8/–	a day
Teaming, 1 man, 2 horses	...	16/–	a day
Insulators	...	6½d.	each
Horn Switches	...	18/–	each

The cost of another branch line, capable of transmitting 50 hp. over 1½ miles at 2,400 volts, was £162. 25 ft. poles costing 11s. each were used, 2,264 lbs No. 6 B. & S. galvanized iron wire, and double petticoat glass insulators costing 2½d. each. Labour cost the same as above. The country traversed was rocky, and holes were not easily sunk. The Electricity Supply Company put down wells, the depth from which water is pumped ranges from 150 to 175 feet. The efficiency of the pumping plants, water Hp. to E.H.P., is just greater than 40%, Byron Jackson pumps being used.

The representative of the G.E. Company in Los Angeles kindly furnished the following information, concerning the electric transmission and pumping plants in the neighbourhood:—

The Edison E. Co., whose transmission line runs from Santa Ana Cañyon to Los Angeles, a distance of 88 miles, has sub-stations at Colton, Riverside, Pomona, Puento, Pasadena, Dolgeville, Wheltier, Fullerton, Santa Ana, Orange and Anaheim, from all of which branch lines are run to the various ranches, orange, lemon and walnut groves, and the electric motors operated from these lines are used for pumping water.

The Pacific Light and Power Company, of Los Angeles, also has a transmission line from Mentone to Los Angeles, a distance of 80 miles, with sub-stations at San Bernardino, Ettawanda, Ontario, Pomona, Azusa and San Gabriel, from which electricity is supplied in the same manner for pumping purposes.

In addition to these the San Antonio Water Company of Ontario, Cal., have a plant of 750 K.W. in the San Antonio Cañyon. Electricity is transmitted at 10,000 volts over a distance of 8 miles to a sub-station, at which it is reduced to 2,300 volts, and used exclusively for pumping plants at Ontario, North Pomona, Uplands and Claremont. Motors are belted on to pumps which raise water for irrigating orchards, the water being raised from 70 to 200 feet.

The city of Riverside, Cal., has a municipal steam plant of 400 K.W. in addition to 1,000 K.W., which is bought from the Edison Electric Company. All of this power is used in the daytime to furnish current to motors for irrigating ranch orchards near to Riverside. At night electricity is used for lighting purposes.

The Temescal Water Company, at Ethenac, Cal., is operating a steam plant of 500 K.W., which is used solely for operating pumps to irrigate orange and lemon orchards owned by that Company. At the present time something like 6,900 hp. of G.E. motors, and 3,800 hp. Westinghouse motors, or a total of 10,700 hp., are being used for pumping water on to ranches, the biggest motor being 150 hp., and from that down to 1 hp. All kinds and sizes of pumps are used, Addison pumps, Ames Pumps, Jackson centrifugal pumps and Crowe pumps, all being of local or coast manufacture. The depth of the wells varies from 50 feet to 247 feet.

At Ontario the train was taken to Redlands, about 60 miles east of Los Angeles, and a visit was paid to two of

the power houses where electricity is generated. To reach them, a buggy drive of about 15 miles out and in was necessary. The character of the country in the neighbourhood of Redlands was fertile and well cultivated, but subsequently became rugged, rough and uncultivated. In the whole of this district deep well pumps were used. After returning to Los Angeles, Bakersfield was visited in order that the pumping plants in that neighbourhood might be inspected. To supply Bakersfield and its neighbourhood, electricity is generated in Kern River Cañyon, 13 miles distant. It is transmitted at 11,500 volts to sub-stations, and there stepped down to 2,080 volts. For irrigating purposes, the 11,000 volt transmission line is tapped, and the voltage reduced to 500, in a very similar manner to that adopted in the Pomona district. The output of the Bakersfield plant is about 1,800 hp. In the immediate neighbourhood there are 29 motors averaging 30 hp. each, and used for pumping; the largest motor is 40 hp. All pump houses visited in this neighbourhood contained centrifugal pumps working with lifts not exceeding 50 feet, often less. Most of the pumps were belt connected to the motors, although one direct connected plant was seen in operation. Besides acting to some extent as a safety device, a belt drive is convenient, in that it permits adjustment of the pump speed to suit working conditions. The pump houses in this neighbourhood are used for watering cattle, and for irrigating pastures on which cattle are fattened. The power rates charged are on a base rate of 5d. per B.T.U., with discounts calculated on the amount of the monthly bill. On a monthly bill of 20/- the charge would be 4d. a unit, and on a monthly bill of £10 and upwards the charge is 1¼ per unit. The distance of furthest pumping plant from the power house is 30 miles.

There are numerous irrigating schemes dependent on electric transmission, in addition to those which were visited. Most of them use electricity produced from water power, but some are operated from steam plants. It matters not how the electricity is produced so long as it can be sold at a price to render irrigation payable. Writing on the subject of irrigation, Mr. Newell, Chief of the Hydrographic Branch of the U.S. Survey, expresses the following views on the transmission of power:—"The facility for transmitting power has revolutionized many industries. Such is the condition in Southern California, where a number of generating stations have been erected in various cañyons, and the electric wires converging towards Los Angeles, make possible numerous industries in the vicinity of the city, and drive many small irrigating pumps. Cheap power means ability to pump water, and water supply in turn, makes possible an extension of irrigation, and this is the principal step towards more homes and a settled population."

The following extracts from the Second Annual Report of the U.S. Reclamation Service may also be of interest, because they bear on the same question. The report deals with projects under consideration and work carried out. The quantity of water which it is customary to apply to the land for irrigating varies considerably according to circumstances. Where water is plentiful it is frequently wasted, or has been in the past, and applied in such quantities as to injure plant life. It is not only necessary to apply water, but equally necessary to prevent the soil from becoming water-logged. Constant application of water without adequate provision for drainage has in some places caused much injury. The quantity of water necessary to irrigate an acre, as estimated by various water companies in Southern California, ranges from 1

miner's inch to 5 acres, to 1 miner's inch to 10 acres, the miner's inch in this connection being defined as a quantity equalling 10,800 gallons in 24 hours. This quantity is required when the water is delivered in pipes, or cemented channels close to the trees or vines to be irrigated, and is used during the hot months of May to October. It is equivalent to a total of 880 points according to Australian units. With care and cultivation this quantity has been found sufficient for some orchards.

The method of applying water governs to a large extent the amount used. In the case of alfalfa, flooding is usually practised. With small grains, the water is run in furrows, in orchards this method is sometimes adopted also, but sometimes it is taken to each tree. In the latter case, a basin about 6 feet across and 6 inches deep is formed round each tree, and partially filled with water. The water is applied very slowly, several days being spent in watering 5 acres. When dry, the ground is thoroughly cultivated. The annual charges for water in Southern California, where this economy is practised, have been as low as 12s. per acre and from this to 24s. or more per acre. In the case of the San Diego Flume Co., it is stated that water has been sold for $600 per miner's inch, this being sufficient for 10 to 20 acres. At this price the charge for water would be £6 to £12 per acre. The annual charge for water, taking the arid region as a whole, has averaged by States from 2/1 to 8/- per acre, or 5/- per acre for the entire country.

The conditions in Southern California, while they may be considered as exceptional, indicate the limiting or ideal conditions of economical use of water. For good farming in other parts of the arid region, 12 inches of water in depth during the crop season should be sufficient, except in the case of alfalfa and other forms of forage which are

cut a number of times, when at least from 4 to 6 inches should usually be given to each crop. Successive years of deficient rainfall in California from 1897 to 1900 served to prove that with careful cultivation, crops, orchards and vineyards could be maintained on a very small amount of water. In some cases an amount not exceeding 6 inches in depth of irrigating water, was applied during the year, this being conducted directly to the plants, and the ground kept carefully tilled and free from weeds.

In Colorado, measurements have been made for several years to determine the duty of water in different localities, and under different conditions. Average made from the records shows that when the water is measured at the margin of the fields to be irrigated, the amount required varies even when care is exercised in its distribution from 1·25 to 2·5 acre feet per acre irrigated. The average duty of selected examples having little loss in transit compiled from measurements made in the years 1899, 1900 and 1901, is given as 1·63 acre feet, 19·56 inches. The average of low duties is given as 5·7 acre feet, the average of all is 3·98. The variation in all examples is from 1·2 to 15·44. The average depth of water applied to some of the different crops is given as follows:—

Alfalfa	3·39 feet	Potatoes ...	3·94 feet
Barley	1·49 ,,	Sugar Beets ...	2·15 ,,
Corn	1·4 ,,	Wheat	2·68 ,,
Oats	1·73 ,,		——
Orchard ...	2·76 ,,	Average ...	2·31 feet
Peas	1·28 ,,		——

The character of the soil, the temperature, and the wind movement, the cost of labour, introduce so many conditions that no fixed rule can be laid down. As regards charges for water, at Corona, or South Riverside, in Riverside County, the charge in 1900 was £3 per acre foot of water.

Owing to the drought, there was but one-half the usual amount of water delivered during the year; the supply was principally obtained from a pumping system. From numerous pumping plants near Azusa, in Los Angeles County, water has been sold during the years 1898 and 1900 at the rate of £3 12s. to £6 per acre foot. At Ontario, £2 per acre irrigated is charged each year. At Hollywood, a suburb of Los Angeles, 6d. a 1,000 gallons is charged, or £6 10s. per acre foot. The land is used for growing lemons. The annual charge for the irrigation of citrus lands in Southern California, varies from £1 to £6 per acre, and probably averages £2 per acre irrigated, the supply being from 12 to 36 inches in depth of irrigation water. In addition to this there is about 15 inches of winter rain. The citrus fruits need about twice as much water as the deciduous fruits, and alfalfa requires more than either.

Value of Land.—The open range of the arid regions is generally stated to be capable of supporting a cow for every 20 or 30 acres. The same land, when watered and put in alfalfa, will frequently feed 10 times as many cattle, or in orchards with favourable climate will support a family of 3 or 5 persons. The open range may have a value of 2/1 per acre, and under irrigation the value may rise to £10 per acre, or even £100 per acre when in orchards. In Arizona, with continuous warmth and sunshine, and with the necessary water, intensive farming is practised, and it is estimated that a family of 5 persons can be well supported upon 20 acres or even less if covered with orchards. Between Kuna, Mexico, the Colorado River, and the desert Mesa to its east, there are 50,000 acres of fertile land, of which 10% is now under cultivation producing alfalfa, corn, wheat, and some Egyptian cotton. Crops can be grown every month of the year. Alfalfa is cut from seven to eight times, producing 10 to 15 tons

annually per acre. Corn and maize bear with like abundance, two crops frequently being harvested in a year. Orange land with water, but without trees, is estimated to be worth from £50 to £60 per acre, and with bearing trees, the price ranges from £200 to £400 per acre, if the location is good, with first class water rights and navel trees.

In the San Joaquin Valley, the average annual rainfall is less than 9 inches, and non-irrigated lands are not worth more than £2 an acre. The same lands irrigated and developed by orchards and vineyards are worth approximately £100 per acre, and are said to yield net returns of from £10 to £20 per acre per annum. In Nevada the principal crops are alfalfa, which is cut 5 or 6 times a year, yielding about 1 ton per acre per crop. Barley, oats and wheat average 25 to 30 bushels per acre, and some instances of 75 bushels per acre have been known. Grapes thrive and yield good crops of excellent flavour, 3 acres having produced 5,000 lbs. Pomegranates, peaches, apricots, vegetables and small fruits also do well. In 1902-3 improved lands sold for £5 per acre, and unimproved lands at 6s. to £1 per acre. In Oregon, land on which sugar beet is cultivated is said to be worth £40 per acre.

Size of Farms.—Small farms are characteristic of successful irrigation. Throughout Utah the average size of an irrigated area is less than 30 acres. By means of this a family is supported in comfort, and there is a gradual increase in wealth, and there is an absence of the loneliness and depression existing where the population is very sparse.

Increase of Work.—It is not believed that the whole of this area is irrigable, but that about 10 times the area at present irrigated is so. It is stated that within quite a few years, tracts of country which were sandy wastes and

suitable only for grazing after unusual rains have now been changed into prosperous agricultural centres, and that families are making a living, and getting on in the world by cultivating 15, 10 or even fewer acres of land which until the introduction of water had scarcely any value. In the season 1899 to 1900 a severe drought was experienced. For ten years there had been less than the normal rainfall and for two years the rainfall had not reached one-half the average for the region. The supply from underground sources did not diminish as had been expected. The extra care, arising from the need for economy, had the result in some cases of increasing the yield. Mr. Newell remarks in his book on this subject, that there is probably a large amount of underground water to be obtained by the use of cheap power such as that obtained by electrical transmission.

Artesian Wells.—Artesian wells are found in some parts of California. As the number is increased the pressure diminishes, and later still those wells near to the edge of the basin cease to be artesian. This condition of affairs has also been experienced elsewhere. All the artesian wells near Denver, Colorado, have ceased flowing, and water is now obtained from them by pumping. Out in the country lower down, the basin wells still flow. Some wells have ceased to flow because of mechanical defects, they have either choked, or the water escapes into pervious rocks below the surface. In some localities where wells were abandoned because the water did not rise to the surface, or the flow was unsatisfactory, the casings have been drawn for use elsewhere. The water has continued to rise from the bottom of the well and to escape into the higher porous strata, permitting a continual outflow from the artesian water-bearing rocks, but it is unnecessary to dwell at length on this aspect of the subject. Water

obtained from these sources is frequently impregnated with gypsum, much land irrigated with this water has been greatly injured by the unskilful use of water. It is believed, however, that by careful consideration, it will be possible to reclaim large areas of arid land, without ultimately injuring it by the alkaline waters. It is stated that in some places water containing as much as 400 parts per million of alkali is being used successfully for irrigating. The extent of the arid regions in the U.S of America is roughly one-half of the whole area. It is understood that regions having 20 inches rainfall per annum or less are arid.

The extent of the arid regions of Australia does not exceed two-thirds of the whole area. The work of reclamation in America appears to have been started by private enterprise. As its success and possibilities became apparent and as the work increased, water rights called for legislation. Progress continued and justified the creation of a Government Reclamation Department. The officers of this department have been selected from amongst the employees of the most successful commercial enterprises, the most skilful scientists. These men investigate conditions prevailing in arid regions, the best methods of reclaiming land, of conserving and using water, the primary object being to make homes for the workers, for those people without large capital, but with health, strength, ability and willingness for hard work. No settler is allowed to take up more than 160 acres of land. To those interested in the subject, complete information can be obtained on reference to the publications of the U.S. Gov. Reclamation Department, and to Mr. Newell's excellent book on Irrigation to both of which the author is indebted for much of his data. As remarked above, Mr. Newell is the Chief Engineer of the Reclamation Service, and is probably the highest authority on the subject of irrigation in America.

Before any scheme for pumping water by electricity in Australia could be suggested, it was necessary to produce electricity at a price to compare with that for which it is produced in California. Until recently, at all events, cheap electricity in California was derived from water power, although coal and oil fuel are now being used to some extent also. Following the great improvements recently made in steam turbines, and the latent possibilities of large gas engines, it is probable that much greater developments will take place in the near future.

There are practically no water powers in Australia as in California and resort must be made to coal. Until quite recently, electricity could not be purchased in Sydney at a lower price than 3d. a unit. This price was not unreasonable taking all things into account. The author does not think it is unfair however, to say that recently there has been a genuine attempt to provide cheap electricity, not merely for lighting purposes, but for industrial purposes generally.

The average daily load curve on the Council's plant shows that during a large part of the day much of the machinery is idle, and must by the very nature of things remain idle. Suppose, however, that it was not idle, the additional cost to the Council would not exceed ·342d. per unit sold. All charges except variable charges remain unaltered. It is better then, that the Council should sell at any price exceeding say ½d. a unit during those portions of the 24 hours, than that the plant should remain idle. The cost of transmission lines and the losses in transmission, within a radius of 50 miles at any rate, need not exceed the present costs, provided that overhead construction, instead of underground construction is adopted as in America, and provided that the voltage is raised suitably. A scheme for transmitting electricity inland some 50 miles or so, through Ashfield, Burwood,

Strathfield, Parramatta and Penrith with a branch to Liverpool is quite practicable as an engineering enterprise, and has the following advantages in respect of the irrigation problem. The total equipment of transmission lines, pumps, motors, transforming devices, and so on, could probably be installed, and put to work at a cost not exceeding £100,000. There would certainly be a return on the Capital Expenditure, because there would be a sale of electricity for lighting, power, and industrial purposes, in townships traversed by transmission lines.

The difficulties and delays in obtaining the best results from irrigated land, which must always be expected under new conditions of soil and climate, would be of small consequence, because the enterprise would not be absolutely dependent on these results for earning revenue. It would not be necessary to sink large sums of money in works which would be of no value if the scheme proved unsuccessful, a large portion of the cost would be incurred in electrical apparatus which could be used in connection with other works, should the irrigation prove unsuccessful. If successful, it would be the means of educating farmers to irrigate, and to practice what is known as intense cultivation. A skilled class of men would thus arise in readiness to turn to account waters conserved in dams and distributed by ditches. Such works cost great sums of money; they depend entirely on the irrigator for their success or failure. It is not necessary to build a large power house for the production of electricity for transmission, two of these already exist in Sydney, from either of which, power could be transmitted during certain periods of every 24 hours.

To anyone who travels in Europe or America, the immense progress which is being made in the application of electricity to all kinds of old industries and to the

development of new industries, cannot fail to make an impression. Electric transmission is an accomplished fact, and a successful commercial proposition. If electricity is supplied at 1d. per unit, to motors operating pumps with a 50% overall efficiency, the cost of raising from a depth of 100 feet sufficient water to cover an acre of land one inch would be approximately 1/5, or if irrigation is practised on the same scale as in California, the cost of electricity would be from 23/- to 67/- per acre per annum. As stated before, the average cost of irrigating citrus fruits in Southern California varies from £1 to £6 per acre, and probably averages £2 an acre. It would appear that there are possibilities in the proposition. The author does not suppose that the City Council could possibly take up such a scheme, and is not prepared to suggest who should do so. The possibilities, the far reaching effects of the success of such a scheme justify further investigation, if they do not justify the experiment, particularly in a new country.

TRANSVERSE TESTS OF JARRAH MADE AT SYDNEY TECHNICAL COLLEGE.

By JAMES NANGLE, F.I.A.

[With Plates XXIII. - XXV.]

[*Read before the Engineering Section of the Royal Society of N. S. Wales, September 19, 1906.*]

TABLES No. I. and II. contain results of transverse tests made on twenty pieces of West Australian Jarrah. The test pieces were approximately 2 inches by 2 inches in cross section, and all but two were 24 inches long. They were tested for moduli of rupture and elasticity on a span—in all cases but two—of 22 inches, in the 50,000 pounds Olsen testing machine at the Sydney Technical College. A piece of wood about 2½ inches long was placed under the centre bearing piece of the machine, on top of each specimen.

Deflections were taken at every 200 pounds of load by means of a deflectometer. This deflectometer consists of a straight edge which bears on pins, in the neutral plane of specimen, over each bearing. Attached to the straight edge is a magnifying arm or pointer. The short arm of the pointer is attached to a pin in the specimen; the end of the other arm indicates, to an enlarged degree, the deflection on a scale which is attached to one end of the straight edge. The advantage of the apparatus is that the error due to crushing at bearings is eliminated from the deflection readings, since the latter are taken, not from the bed of the testing machine, but from the neutral plane of the specimen. The load taken for the calculation of the modulus of elasticity was about one-fifth of the breaking load.

TABLE I.—SHEWING RESULTS OF TRANSVERSE TESTS OF JARRAH.

Date of Test.		Specimen number	Size of specimens in inches. Length	Breadth	Depth	Area of cross section.	Span	Breaking load in pounds.	Failure.	Time of Test in min.	Rate of load applied in pounds per min.	Modulus of Rupture.	Modulus of Elasticity
17 Nov. 1905	1	1	26	2·01	2·01	4·04	24	3800		...	...	16846	2117334
24 Nov. 1905	2	2	26	2·03	2·02	4·106	24	3890 4600	tension compression	14	328 6	16823	2504317
18 May 1906	5	A	24	1·96	1·97	3·87	22	4575	tension	17	269·1	19949	2142835
„	6	B	24	1·99	2·03	4·08	22	3560	tension	11	318 2	14367	2124252
„	7	C	24	1·99	1·96	3 9	22	2200	tension	7	314·28	9353	1641358
„	8	D	24	1·99	1·97	3·92	22	3990	tension	12	332·5	16877	2286215
8 June, 1906	15	E	24	1·98	2·01	3 97	22	2550	tension and compression	10	255	10678	1864916
„	16	F	24	2	2·01	4·02	22	2400	tension	8	300	9850	1439541
„	17	G	24	1·99	2 0	3 98	22	2600 2610	tension compression	7	378·57	10833	1647763
„	18	H	24	2	2·0	4	22	2650 2975	slight compression tension	13	228·84	12271	1721120
„	19	I	24	2	2·02	4·04	22	2850	tension and compression	12	237·5	11639	1647272
22 June, 1906	20	J	24	1·99	2·02	4·01	22	2400 2575	compression tension	11	234·09	10622	1441411
6 July, 1906	33	K	24	2 08	2 08	4·12	22	3295	... ...	5	659	12998	1425053
„	34	L	24	2·08	2 08	4·12	22	3130	tension	6	521·6	12347	1710064
„	32	M	24	2 08	2·04	4·14	22	2700	tension and compression	6	450	10546	1584227
„	28	N	24	2·08	2·08	4·12	22	2700	compression	5	540	10650	1650062
„	31	O	24	2·08	2·03	4·12	22	2820 2470	tension tension	5	494	9748	1844187
„	30	P	24	2 08	2·02	4·1	22	2970 3080	compression tension	7	440	12270	1704694
„	29	Q	24	2·08	2·08	4·12	22	2640 2850	slightly in tension tension	4	600	11242	1650062
„	35	R	24	2·08	2·08	4·12	22	2150 2480	tension tension	4	621·25	[illegible]	[illegible]
									Averages			[illegible]	[illegible]

TABLE II.—SHOWING DEFLECTIONS (In 100ths of an inch) OF SPECIMENS OF JARRAH.

Specimen Number.	LOAD IN POUNDS.											
	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400
2	·007	·029	·049	·069	·079	·109	·127	·145	·169	·186	·205	
A	·013	·034	·05	·067	·083	·099	·117	·135	·151	·171	·179	·197
B	·014	·03	·047	·062	·078	·094	·112	·128	·147	·164	·183	·203
C	·022	·042	·063	·082	·102	·126	·147	·176	·195			
D	·008	·026	·045	·06	·078	·092	·112	·13	·15	·165	·2	
E	·02	·05	·066	·09	·113	·134	·158	·184	·214			
F	·02	·046	·068	·089	·11	·132	·155	·176	·202	·228		
G	·02	·041	·064	·086	·108	.13	·152	·176	·202	·23		
H	·018	·038	·058	·078	·1	·12	·14	·162	·184	·21		
L	·016	·04	·06	·08	·102	·124	·144	·166	·191	·22		
N	·018	·038	·06	·078	·1	·121	·142	·168	·192	·22		
Q	·018	·038	·058	·078	·098	·119	·14	·163	·188	·212	·23	
P	·018	·037	·056	·074	·091	·11	·12	·15	·172	·195	·22	
O	·012	·034	·06	·081	·105	·128	·152	·178	·206	·236		
M	·016	·039	·058	·076	·097	·118	·138	·16	·183	·197	·211	
K	·024	·044	·066	·083	·104	·124	·144	·166	·188	·21	·231	
L	·016	·036	·055	·072	·09	·11	·128	·15	·169	·193	·219	
R	·024	·049	·072	·094	·118	·143	·165	·192	·218			

I am much indebted to Mr. R. T. Baker of the Technological Museum who has kindly undertaken to supply timber specimens properly classified for the testing work which I propose to carry on. I have also to acknowledge the help given by Messrs. Farrell and Martin, two of the advanced students, who have given much assistance with the making and reduction of the tests.

MR. NANGLE'S EXHIBIT OF MICROSCOPIC SECTIONS OF AUSTRALIAN TIMBER.

The exhibit consisted of transverse sections of Ironbark, Red Slaty Gum, Tallow-wood, Blackbutt and other species of Eucalyptus, also photomicrographs of the sections. Mr. Nangle stated that he had for some time been engaged in an examination by the microscope of the species of Eucalyptus which closely resembled each other to the naked eye, with a view to detecting differences of an exact character. He hoped to be able to determine something in the way of a type specimen for each species when subjected to microscopic examination. The subject was a large one, and as yet but little progress has been made. With great diffidence he brought the specimens and the results he had so far obtained before the Section. By the kindness of Dr. Quaife the specimens were projected, greatly magnified, on to the large screen, and members were able to judge for themselves as to what differences were noticeable.

Mr. Nangle stated that so far he had noticed, with certainty, the following points:—1. That in sound dense timbers like ironbark, the vascular cells were small, (compare *Plate 23*, figs. 1, 2, and *Plate 24*, fig. 3). It will be seen that in Ironbark the cells are much smaller. 2. The medullary rays were strong and well defined, (compare *Plate 24*, fig. 4, and *Plate 25*, fig. 5). The medullary rays are much stronger in the Ironbark than in the Red Slaty Gum. In the latter they are deformed. 3. That scattered cells in the woody tissue were sparse, (compare *Plate 24*, fig. 4, and *Plate 25*, fig. 5).

Some timbers, like Tallow-wood and Blackbutt, were very much alike in transverse section, but a difference was noticeable in longitudinal sections, in which, in the case of Tallow-wood, the vascular cells were shorter than in Blackbutt on account of the greater twisting and interlocking of

grain in the former timber. From what he had learned, Mr. Nangle thought that an architect or engineer might be able by means of the microscope to say as to whether a timber belonged to a good class or not. In so far as this, the method of microscopic examination together with evidence afforded by the naked eye would prove useful. It had to be remembered that the engineer and architect had to judge the timber in the form of scantling, and had not the means of judging by bark, leaves, or fruit.

Mr. J. H. Maiden addressed the Section at the invitation of the Chairman. He expressed his pleasure that Mr. Nangle had taken up this work of utilizing the microscopic structure of our hardwoods for purposes of diagnosis. He had done some work in this direction himself, but pressure of other duties had caused it to be laid aside; still, he had never ceased to take an interest in the subject that Mr. Nangle had begun so auspiciously. He ventured to refer to his remarks as President of this Society (these Proceedings, Vol. xxxi., 58, 1897). He also exhibited one "book" of 100 of Nördlinger's beautiful wood-sections for the microscope, which would be models for sections of Australian woods. Indeed Nördlinger's sections, of which the speaker has 1,100, include a number of Australian ones.

The work on which Mr. Nangle has embarked is so vast that it might well be taken up by a number of men working to a common end, otherwise the present generation would not see the work far advanced. He wished Mr. Nangle every good wish in his research.

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